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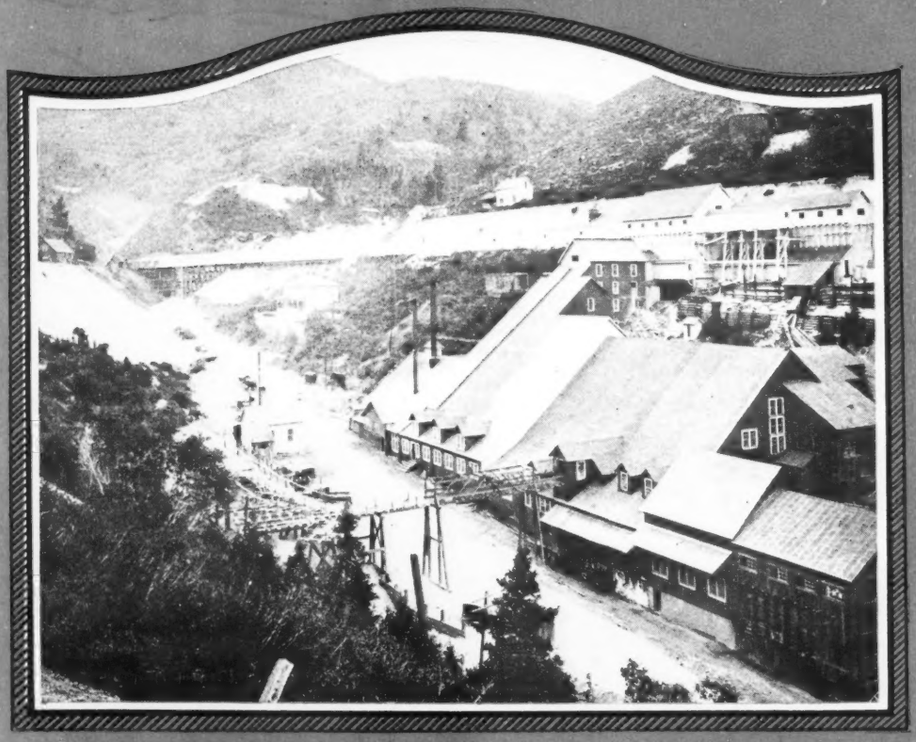

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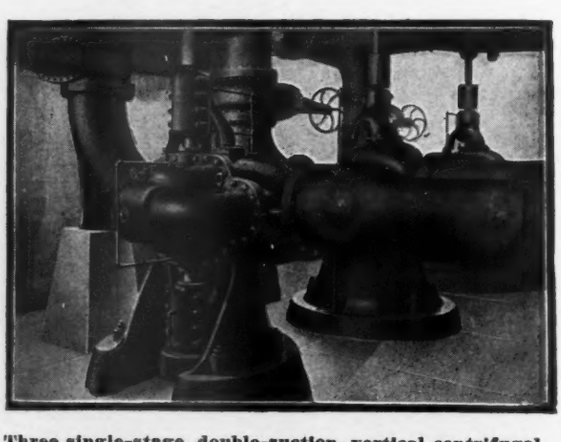

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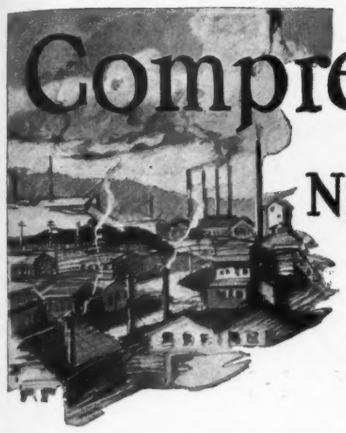

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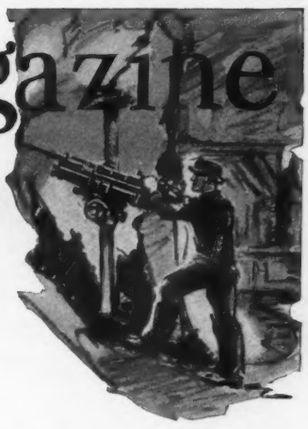


VOL. XXX, NO. XI

NOVEMBER, 1925

Production of Pyrex a Monument to Progress in the Glass Industry

Corning Glass Works Developed This Very Valuable Glass After Years of Intensive Research and Exhaustive Experimenting

By S. G. ROBERTS

GLASS is one of the most widely used substances of man's making. Even so, it is undeniably true that the public at large knows less about the composition and the manufacture of glass than it does about any other product employed as variously and as extensively.

It is not our purpose to tell the story of the antiquity of glass, but evidence there is that the Egyptians knew how to make it 7,000 years ago. Indeed, there were depicted on the walls of the tomb of an Egyptian King of the fifth dynasty—that is, 4,000 years before the Christian era—glass workers in the act of blowing a bottle. However, notwithstanding this ancient lineage of glass, it is safe to say that more has been done towards developing glass for a multiplicity of purposes in the last half century than was achieved during the whole previous history of the product. This advance has been mainly in direct response to the greater demand for glasses capable of meeting extremely diversified services.

In this important department of industry, no plant has done more in advancing the art of glass making than the Corning Glass Works of Corning, N. Y. This enterprising and well-known establishment has to its credit a record of unique accomplishment covering a period of more than half a century. The Corning Glass Works has long specialized in producing glass of one sort or another capable of meeting exacting requirements. In short, the company has distinguished itself by producing and by manufacturing glasses that would stand up under service conditions under which ordinary glasses would fail.

In the course of its growth, the Corning Glass Works has expanded continually and has added department after department until the main plant has become an aggregation of buildings boasting a floor space of more than 612,000 square feet. We have not at our disposal space available to describe in any detail the many different activities that are carried on in the several associated departments, so we shall have to confine the present story to work centering about the production of one class of glass—that is, glass distinguished by an exceptionally low coefficient of expansion.

Paintings by Beni-Hassan appearing on the walls of the tombs of some of the ancient rulers of Egypt have clearly recorded the fact that the art of blowing glass was known to the Egyptians fully 4,000 years ago. The accompanying illustration is an adaptation of two of Beni-Hassan's paintings.

It is painfully familiar to most of us how promptly a hot tumbler cracks when filled with cold water; and we can easily recall numerous other examples of the splitting and the shattering of glass containers when suddenly heated or chilled. This fracturing was due mainly to unequal stresses abruptly developed in the glass walls by opposing movements of expansion and contraction. This sensitiveness of most glasses has been a feature of them for many centuries, and it has imposed great care in handling them and it has also made it impossible to utilize glass for certain purposes for which it was suitable because of its transparency.

The physical property which is technically termed the coefficient of expansion is the measure of linear expansion or contraction that takes place when a substance is heated or cooled 1°C.—that is, 1.8°F. It was the desire of the experts of the Corning Glass Works to find ways to greatly reduce this coefficient that led them to undertake a line of research to this end more than twenty years ago. The object of this investigation was to produce, if possible, a type of glass that would meet the rigorous conditions imposed in railway signal work in which lantern globes and semaphore bull's-eyes were exposed to sharp and rapid temperature changes. In passing, it should be said, that the Corning Glass Works has supplied glass for this purpose to

the railroads of the United States for quite half a century.

When the Corning Glass Works began experimenting, it was known that there was being manufactured in Jena, Germany, a glass having an expansion coefficient of 0.0000064. This was a borosilicate glass, designated by its makers as thermometer glass 59'''. The facts that it was a borosilicate glass, and that it had the lowest coefficient of linear expansion among the then existing glasses, were indications that assisted the early investigators.

The first of the low-expansion glasses developed by the Corning Glass Works to be marketed in large quantities was given the trade name of "Nonex." It was the outcome of patient and persistent labors, and it was capable of meeting every condition imposed by railway signal service. It was not enough merely to produce a glass of notably low expansion, but it was equally essential that the glass should have durability and that it should faithfully transmit its true colors under all atmospheric conditions so that there could be no mistaking a semaphore's message of "clear," "caution," or "danger." It is easy to realize that security of life and property may hinge upon glass standing up despite any state of the weather.

In consequence of its success in evolving low-expansion glasses for the uses mentioned, the Corning Glass Works permanently organized a research laboratory in the plant, and in doing this the company set a precedent for the glass industry in this country. At the present time, this laboratory is large and splendidly equipped and administered by a corps of experts continually engaged in testing the plant's regular products and in bettering them whenever and wherever that may be possible. Furthermore, these highly trained technicists carry on investigations looking to the development of other commercial products and to the solution of glass problems submitted to them from many directions. It is thus that the company is able to turn out the exceptional in the art and to do this while adhering rigidly to a very exacting standard of excellence.

Besides satisfying the needs in the field of railroad signaling, Nonex was soon found admirably suited to such uses as lamp chimneys, inner arcs, battery jars, etc. This was merely another instance of how a material developed in the first place for one service could be adapted to other services. Only a person familiar with the technology of glass could appreciate the various obstacles that were overcome in evolving Nonex. This was especially true when it came to introducing the coloring chemicals required to give the lantern globes and bull's-eyes their prescribed hues, because the colors at first had decidedly different effects when combined with the heat-resisting glass.

And now we come to a still more amazing achievement: the evolution of a borosilicate glass possessing greater heat-resisting properties than Nonex—a glass that could be employed successfully in the making of cooking utensils that could be used in an oven without fear of breaking. Never before had a glass dish been fashioned that could be subjected to those severe conditions and survive unharmed. It was necessary, of course, to give the baking dish fairly thick walls. This, in itself, presented a difficulty, because any lag in the transfer of heat through the walls would induce unequal expansion stresses unless the coefficient of expansion of the glass mass as a whole could be kept so low and the transfer of heat made so rapid that any stresses set up would be of very brief duration and of well-nigh negligible strength. What was finally accomplished can best be grasped when it is known that "Pyrex" baking ware—for so the new glass was called—remains unin-

Much water and a large volume of compressed air are used in the different departments of the Corning Glass Works. Here we see some of the turbine-driven centrifugal pumps and big compressors that meet these requirements.

Fig. 1—This general view of the Corning Glass Works gives only a hint of the magnitude of the plant.
Fig. 2—Automatic machine which blows Pyrex nursing bottles.
Fig. 3—Placing a newly made lantern globe in the lehr to remove internal stresses by annealing.
Fig. 4—Final step in blowing a large Pyrex cylinder.
Fig. 5—A preparatory step in blowing a large Pyrex cylinder.

jured even when removed from an ice box and placed in an oven.

It was not enough to produce a glass of low expansion in order to make the glass suitable for oven use; the men in the laboratory had also to give the glass exceptional sturdiness so that the cooking utensil would be strong enough to withstand the rough handling normally expected in the average kitchen. Furthermore, the technicists had to see to it that the glass would be capable of resisting the corrosive action of the acids developed in the liquids of cooking foodstuffs. After several years of experimenting and a wide test use of Pyrex oven ware, the Corning Glass Works was in a position to offer with confidence, in 1915, glass cooking utensils of several sorts that could be sold to the housewife and others with ample guaranty of satisfaction. Since then, these unique commodities have won for themselves an enviable position and a measure of recognition that has been widening apace.

Top—Gathering a gob of glass on a blowpipe.
Left—Blower blowing a gob of glass into a bubble preparatory to finishing the work in a mold.
Right—Blower withdrawing a Pyrex beaker from an opened mold.

Some of the reasons why Pyrex oven ware has won popularity are: it can easily be kept clean—in fact, promptly shows when it is soiled and, therefore, is especially sanitary; it is exceptionally durable for glass, and will give years of service if handled with reasonable care; it is unusually efficient in the economical use of oven heat, and, accordingly, Pyrex utensils bake foods more quickly than do similar utensils of metal or earthenware; and, finally, a Pyrex cake pan, for instance, will bake a cake evenly on the bottom, the sides, and the top. The last two advantages of Pyrex are due to a physical characteristic which causes the glass to transmit to the cooking food stuffs much of the radiant heat which is generally reflected and not transmitted by utensils made of other materials.

In a series of tests made in the laboratory of the Corning Glass Works, it was brought out that a tin dish took up in a gas oven only 50 per cent. and in a coal oven only 31 per cent. as much heat as a glass dish. Other experiments revealed that there would be a fuel saving of substantially 50 per cent. in a gas oven when glass was substituted for a tin dish. Strange as it may seem, the glass dish, even though transmitting heat more rapidly than a tin dish, cools off more slowly than the metal dish when an oven door is opened. This enables a housewife to watch her baking from time to time without running the risk of her bread or her cake falling.

As might have been expected, the special properties possessed by Pyrex invited the adaptation of the glass to other uses; and also in 1915 the Corning Glass Works placed upon the market a full line of flasks, beakers, test tubes, and fabricated apparatus for laboratory use. Today, there is hardly a laboratory in the United States that has not a fairly complete outfit of Pyrex vessels, etc. This is understandable when we keep in mind the fact that this low-expansion glass is peculiarly resistant

to the solvent action of water and the corrosive action of acids. As an insulator Pyrex is especially effective, and for this purpose it has latterly found a field of service in radio. Last, but by no means least, Pyrex is now being worked into nursing bottles for babies, to the abundant satisfaction of many thousands of mothers.

The task of the experts at Corning was not by any means finished when the composition of Pyrex was finally determined. The development of that borosilicate glass brought in its train manufacturing problems of a troublesome nature. To begin with, Pyrex is much more refractory—that is, resistant to heat—than ordinary glass, and requires a temperature of about 200°F. higher than the usual run of glasses. In other words, the melting temperature is 2,800°F., and the glass must be worked into shape before the temperature drops to any marked extent below 2,400°F. This meant that the furnaces in which the glass was melted would have to stand up under unusually severe conditions, and that machinery would have to be modified or devised and men trained to deal with the glass with much greater speed than previously employed in the processes of manufacture.

Manifestly, we are not in a position to tell just what enters into the composition of a Pyrex batch, other than to say that the batch is composed of 50 per cent. Pyrex cullet or scrap and 50 per cent. fresh raw materials in which virtually pure silica sand and borax in one or more forms figure conspicuously. Owing to certain chemical changes that take place during the melting, when a considerable percentage of the batch is volatilized and carried off up the chimney, experience has shown that a definite proportion of the mix must be made up of broken bits of Pyrex. The melting is carried on in continuous tanks of many tons capacity. Each tank is divided into a melting compartment and a working compartment. As the glass passes from the melting chamber to the working end, it settles, clarifies itself, and its heat is gradually diminished until the proper working temperature is reached. The intensity of this working heat is vividly indicated by the dazzling white incandescence of the glass when withdrawn by the gatherer preparatory to blowing or pressing the gob of Pyrex into any desired form.

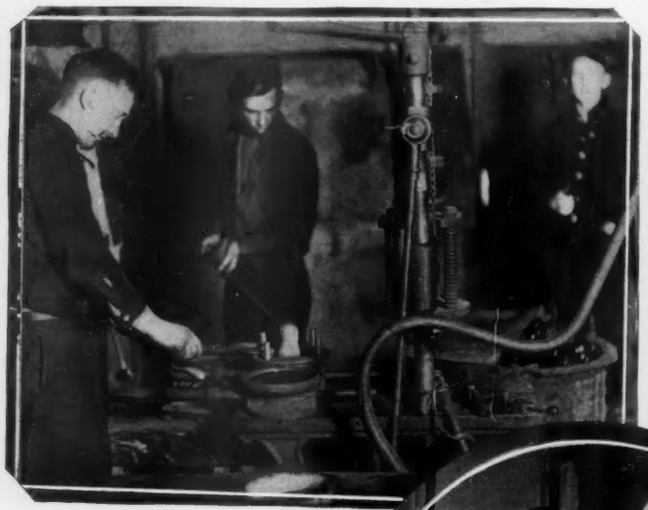
A few of the Pyrex specialties turned out at Corning and intended for electrical and other services.

If the object is to produce a cylinder for an X-ray shield or a cylinder for a visible gasoline-filling pump, the gatherer passes the hollow iron rod, to which the glowing gob of Pyrex is attached, to a gaffer who first blows the glass into a large elongated bubble and then lowers it into a wet 2-piece iron mold which is closed about the bubble by a mold boy. The gaffer then distends the bubble within the mold so that it shall conform to the interior walls of the mold. With this operation completed, the mold boy opens the mold, and the gaffer hands his rod to a lehr boy who carries the article to a near-by annealing oven in which the still hot product is gradually cooled as it travels from one end to the other of the heated oven. It is understood, of course, that the newly made commodity is detached from the blow iron, after which that pipe is turned over to a cracker-off boy who removes the remaining glass so that the iron is ready for use again.

If the work in hand is that of automatically blowing Pyrex baby bottles, their manufacture is accomplished by a somewhat complex and decidedly ingenious machine equipped with two revolving tables and provided with a series of 2-piece molds. A gob of glass is picked up mechanically from an adjacent tank, quickly given a pear-like form by a rotary motion, and then penetrated at the upper end by a plunger that produces an initial cavity. In this state, the insipient bottle is passed to the second table where it is caught by one of the molds, enclosed, and subjected to an air pressure of eighteen pounds that distends the punched cavity and causes the plastic glass to take the shape of the confining mold. This is all done faster than it takes to tell. Both the blowing of the bottle and the operating of the machine are accomplished by compressed air. The manipulation of the glass and the wrist-like movements of the mold spindles are amazing examples of what might be termed mechanical sleight-of-hand. After leaving the blowing machine, the bottles travel by conveyer to a lehr through which they progress slowly during a prescribed annealing period.

Group of clay pots that will be used in the glass furnaces. Each pot can hold about a ton of glass. It takes six months to dry a pot and then it will last something like 60 days in service.

Many of the Pyrex commodities are made in hand-operated presses in which the mold or die parts are kept properly cooled by streams of compressed air. Compressed air has various



Pressing Pyrex headlight lenses.

Blowing Nonex lantern globes.

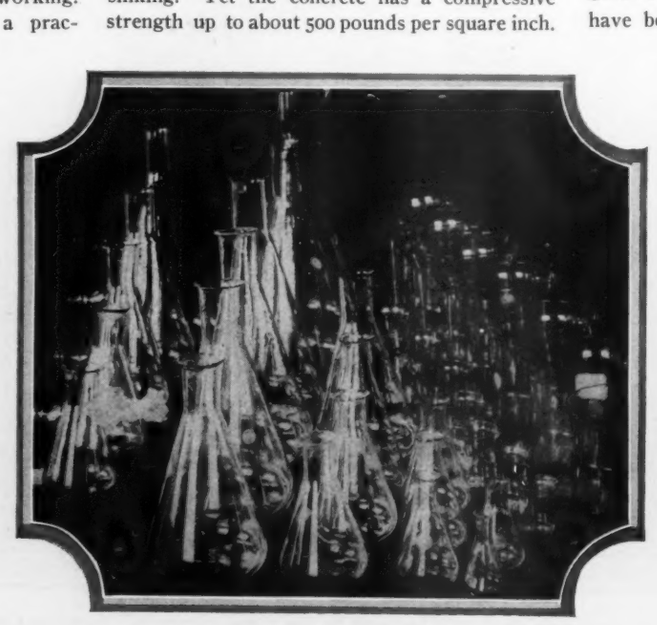
Every Nonex lantern globe is carefully examined before it is packed for shipping.

other helpful services to perform in the production of Pyrex articles of one sort or another; and this very adaptable motive medium is utilized to great advantage in speeding up the work of dismantling damaged furnaces so that they may be quickly repaired. Air-driven drills are able to break through the brickwork and concrete in short order so that the task of rehabilitation can be taken in hand with the least delay.

It is unnecessary to say that every Pyrex article is examined carefully by trained operatives whose sharp eyes are ever on the watch for any defects which might mar either the appearance or the serviceability of the commodity. Only the very best pass to the shipping department, while the rejects go to the cullet pile for remelting and reworking. This not only reduces wastage to a practicable minimum but it insures that high market standard which characterizes the output of one of the world's most interesting and most famous glass plants wherein are employed no fewer than 1,900 persons.

AERATED CONCRETE

IN the housing section of the Wembley exhibition there was shown a cottage constructed of aerated concrete, which may be described as a cellular concrete of sufficient strength for structural purposes and for repair work of practically all kinds. The *Stone Trade Journal*, London, tells us that the principal constituents are cement, "chemical crystals," and water. After these ingredients have been mixed, a chemical action takes place: hydrogen is generated, and this gas forms little bubbles in the mass, depending upon the proportion of crystals. The initial set of the cement takes place around the bubbles before the hydrogen is driven off by air pressure. The material is light in weight: a brick of it will float in water for seven hours and show no signs of sinking. Yet the concrete has a compressive strength up to about 500 pounds per square inch.



Some of the various-sized flasks and beakers made of Pyrex for the man in the laboratory.

THE GOLDBEATER BEATEN

GOLD, through all the historic ages, has been the delight of its possessors; and the art of the goldbeater is one of the oldest still surviving. In the tomb of Tut-ankh-amen, goldleaf, as fresh as if applied today, gleamed on the uncovered furniture and regalia. Egyptian drawings show goldbeaters at work 4,000 years ago. And now it seems that the art is to be superseded, and that those who practiced it will be forgotten.

Dr. Carl Muller, of Berlin, has developed a process by which are produced films of metal incomparably thinner than any hammered gold leaf. Specimens of the metal exhibited by Doctor Muller have a thickness of one millionth of a centimeter or, say one three-millionth of an inch. In this condition the goldleaf is so transparent that photographs have been taken through it; and yet a side-long view across its surface shows the true gleam of the metal. The films also have tensile strength and they may be bent without parting. The process is found to be applicable to other metals: nickel especially, having been handled in the same way with satisfactory results. The invention or discovery is not a laboratory curiosity, but already promises to be of helpful service in various lines.

New Zealand has become the world's greatest dairy center. Though 12,000 miles away from England, the Antipodes now supply that market with butter—having taken the place of near-by Denmark in that respect.

Columbia University has announced that it is now prepared to give a correspondence course in the study of illuminating gas.

Compressed Air a Business Builder

By R. N. BRYAN

IT is not at all uncommon these days to find an increased use of air power coincident with a definite growth in business. In many instances, bigger business goes hand in hand with a wider application of compressed air, as the manufacturer finds in this force one of his most willing and best-paying workers. An example of how compressed air aided, from the outset, in building up a new business is had in the success achieved by the Buffalo Porcelain Enameling Corporation, of Buffalo, N. Y.

It is a matter of pride with the officers of that company that the business has attained its present creditable proportions within five years. When the company was established in 1920, it was primarily designed for the purpose of enameling stoves, with little else definitely in view. Insistent demands from the housewife had forced manufacturers to depart more and more from the old-style cast-iron coal and gas ranges and to furnish a product with enameled surfaces which would be easier to clean, which would be more resistant to dirt and grease, and which would keep their shiny new appearance during the life of the stove. Contrast the beautiful white or pearl-gray enamel front and top of the modern range with the greasy surfaces of the old-fashioned stove. There is scarcely a gas range today which does not make use of enamel in one form or another on the oven door, the overflow tray, or the control handles, and some manufacturers are producing a type of range which has its entire outer surface enameled. It is not surprising, therefore, that the Buffalo corporation considered this a line upon which it could profitably concentrate all its efforts.

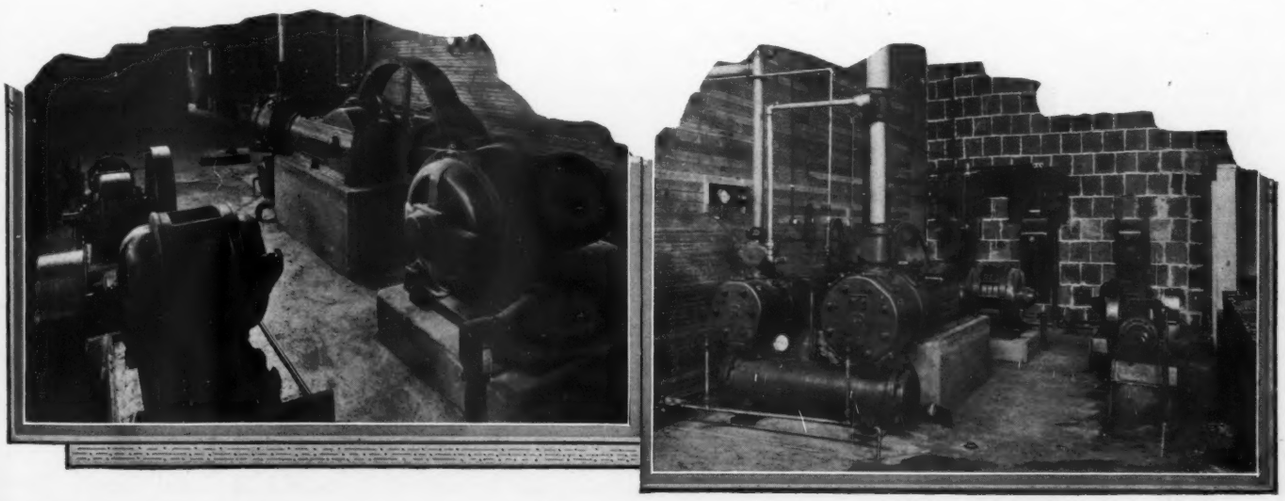
A Pangborn sand-blasting unit in the plant of the Buffalo Porcelain Enameling Corporation.

The first air compressor used in the plant was a medium-sized, Ingersoll-Rand single-stage unit. In the anticipation of increased business, later fully justified, the company installed more machinery, including a sand blast, an 11 and 7x10-inch XRB-2 compressor to operate the blast, eight spray booths, several "dips" for ground coats, a cleaning plant for sheet metal, three furnaces using oil and low-pressure air, etc. The single-stage compressor is still used to provide air for operating the enamel sprays. Both cast iron and steel are enameled; and, with the aid of the air-driven equipment, the company can now enamel 20,000 or more square feet each working day.

The iron used is regular stove plate. The steel is "Armco" ingot-iron enameling stock, or its equivalent. Iron is sand blasted to clear away scale or superficial impurities, while steel is subjected to what is known as pickling. After treatment in a solution of H_2SO_4, the metal goes into a wash tank and, subsequently, into a neutralizing solution that removes all traces of acid and leaves a rustproof coating. An air dryer is brought into play preparatory to applying the first or ground coat.

Before getting away from the subject of the sand blast, it might be well to bring out one very important point in connection with its use in the enameling industry. Blistering of enamel is one of the "bogies" of the business. Dirt, grit, laminations, and pock marks are mainly responsible for blisters, but these impurities and imperfections can be removed by a skilful utilization of the sand blast. Occasionally, a defect crops up after enameling has been started. If it cannot be overcome by additional enameling, the sand blast is the most effective means of removing the entire coat, after which the flaw is cut from the metal. The sand-blast equipment used in the plant of the Buffalo Porcelain Enameling Corporation has proved of value from the first day of operation.

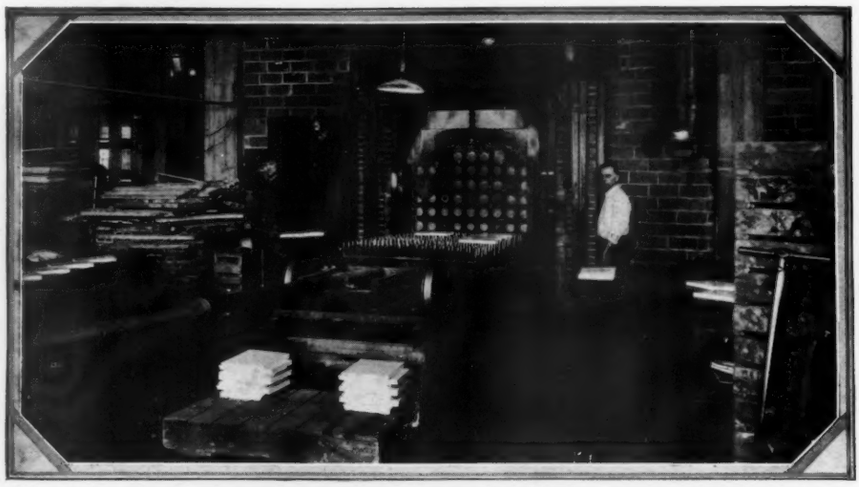
Steel is given a ground coat by a dip or bath, and this is followed by two, three, or four coats of enamel, depending upon the color involved. These coats are applied with a spray gun. Iron receives no ground coat but is given



These electrically driven compressors furnish air for sand blasting and for spraying enamel in the plant of the Buffalo Porcelain Enameling Corporation.

two regular cover coats with the spray. In this connection it is interesting to note that cobalt oxide, rather than tin oxide, is used as an element of the frit, as cover coats containing tin oxide do not cling. The company grinds its frit in pebble mills—using the wet process throughout. Clay and pigment are added as called for.

After each coat has been evenly and smoothly applied, it is necessary to burn the enamel on thoroughly in one of the oil furnaces shown in an accompanying photograph. Parts wheeled into a furnace and thus baked are ready for their next coat as soon as the metal can again be handled. Oil furnaces, as the name implies, use liquid fuel—the oil being atomized in the burners by low-pressure air. Investigation has proved that this air-oil feature makes for economy in operating costs, and this the company was quick to recognize.



Compressed air feeds the oil in this furnace which is used for baking the successive coats on enameled articles.

The Buffalo Porcelain Enameling Corporation does no manufacturing of any kind: it specializes in doing enameling for large manufacturers. One of its biggest fields is the enameling, both inside and out, of refrigerators; and it also handles cast-iron stoves and steel ranges, large and small commercial tacker and flange signs—in fact, signs of any description, and coats great quantities of the pipe railing and "hangers" seen in street cars and subway trains. The carefully prepared enamel stock, as applied by the air spray, gives the products a firm, smooth finish that withstands not only the most severe weathering but also handling for a period of years. In the case of outdoor signs, the weather has little if any effect on the enamel, and there is not much danger of the color fading. Furthermore, enameled signs are not apt to warp.

Commercial signs are in such great demand today for advertising that this field cannot be overlooked by the alert enameling house, particularly one that is equipped for quantity production. The enameled sign is popular both with the buyer and with the manufacturer. The buyer gets his money's worth—that is, a sign that gives long service at low up-keep cost, while the manufacturer is assured a profitable side line that is self-advertising: he is generally permitted to put his name somewhere on his product. There are a number of large establishments that do sign work along with their regular business, and among them is the Buffalo Porcelain Enameling Corporation.

In a modern plant, which aims to combine excellent workmanship with the use of time- and labor-saving methods, compressed air is one of the most indispensable of servants. That this fact is recognized in the enameling industry is evidenced by the extensive application of compressed air in such factories. Farsightedness in the installation of an adequate compressor plant and suitable equipment has already proved its worth in the case of the fast-growing Buffalo concern.

Stenciling the name on a sign with enamel sprayed on by compressed air.

GUTTA-PERCHA

GUTTA-PERCHA does not figure largely in technical literature, but for some special uses it is of great importance. As an insulating material in submarine-cable construction no substitute for it has been found; and the great and continuing increase in cable mileage threatens a prospective shortage of the substance. Produced almost exclusively in the Malay Peninsula, the latex from which it is derived is obtained mostly by cutting down the trees. On the other hand, rubber latex is obtained by tapping, and the trees are not confined to any special locality.

Gutta-percha, while closely akin to rubber, nevertheless differs from it in some essential particulars. As a special insulating material it is superior to rubber but not as elastic as rubber. It changes from a hard to a soft condition, or *vice versa*, with comparatively slight changes in temperature. Its chief use is for electrical purposes; but it is also employed to a limited degree in other directions. Investigations are being conducted looking to the compounding of gutta-percha with other materials.

MORE OPEN CUTS AND FEWER RAILWAY TUNNELS

THE development of high explosives and the perfecting of the "Jackhamer" have made wonderful changes in the speed and the cost of rock cutting, especially where great quantities of material are to be removed. This is strikingly brought out in current railway practice. In new construction, open cuts are now frequently made where years ago tunnels would have been driven; and on the older lines the roofs of many tunnels are being removed.

We have at present a striking instance of this in England, on the London, Midland & Scottish Railway, where the famous Chevet tunnel, constructed by Stephenson nearly 90 years ago, is to be opened to the sky. The tunnel is 702 yards long, so *The Engineer* tells us, and more than 1,000,000 tons of earth and rock will have to be cleared away.

When completed, the cut will be 93 feet deep and 90 yards wide at the top. The work is being carried out without interrupting ordinary traffic.

A report has recently been published by the Engineering Board of Review of the Sanitary District of Chicago on the *Lake lowering controversy and a program of remedial measures.* This document contains the technical basis for the recommendations made by the Board, and has in it much data that will prove interesting and valuable to engineers and others.

Some Typical Uses of Compressed Air in the Manufacture of Aircraft

By P. G. JOHNSON*

THE use of compressed air necessarily varies with each manufacturing establishment, and the possibilities of its use are very extensive. As herein set forth, the applications mentioned are some of the most striking ones that have proved of especial value to a single concern, the Boeing Airplane Company, of Seattle, Wash. Generally speaking, the use of compressed air in and about the shops of this particular concern is increasing.

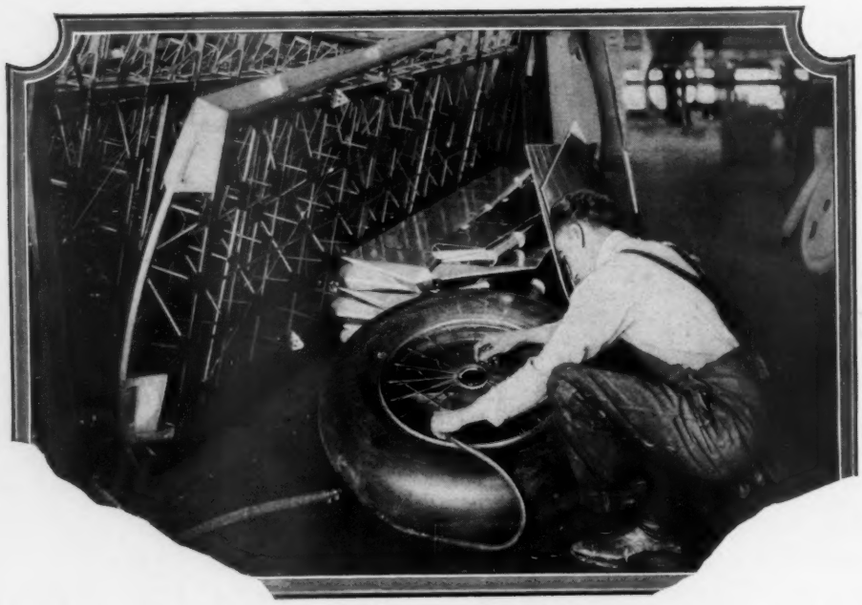
It is true that a clean place in which to work attracts and holds a better class of workmen and also results in better work being done. This is of prime importance in the manufacture of aircraft. To provide such an atmosphere, among other things, a central compressor with sufficient capacity has been installed in the plant to fill such of the demands as could be foreseen. From this unit, numerous air lines lead to every shop in the establishment. These lines are connected not only to the special machines requiring compressed air, but they are provided with suitable outlets so that flexible hose with nozzles can be attached to them.

Twice a month a force of janitors goes over the place and gives it a thorough house-cleaning. For this purpose, air hose are connected to convenient outlets in the main line; and rafters, line-shaft hangers, and supports, all out-of-the-way corners, and every machine in the establishment are cleaned of accumulated dust and grease by air under pressure. Without this aid, it would be impossible to economically clean our shops and to keep them clean. Of course, each milling machine, each shaper, etc., has its own air outlet and permanently attached hose within easy reach of the operator so that after every set-up he can readily blow away all chips and millings from his fixtures and tools.

One of the most commonly used parts about an airplane is the swaged tie-rod, which consists of a swaged wire threaded at one end with a right-hand thread and a left-hand thread at the other. A squared shoulder, back of the thread, and suitable clevis ends make this tie-rod an adjustable tension member in the fuselage and the wing bracing. After

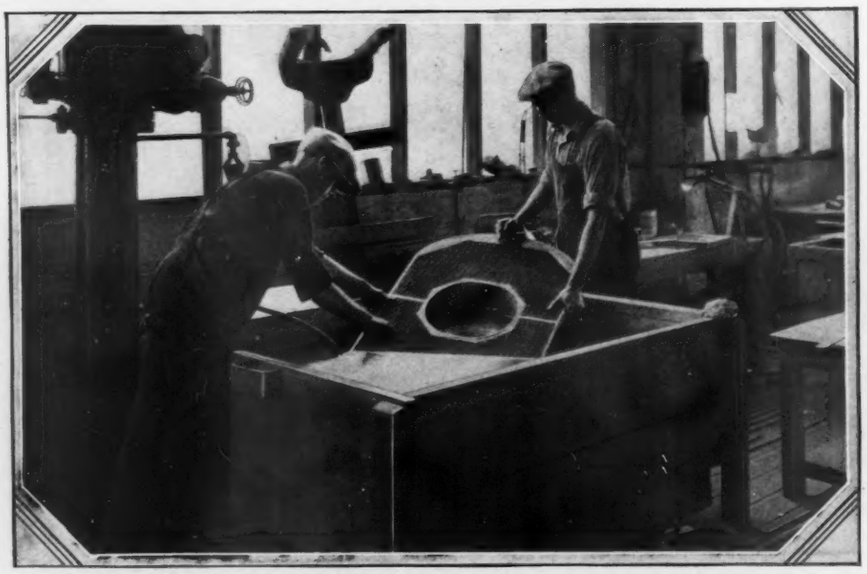
*General Manager and Vice-President, Boeing Airplane Company.

Top—Swaging square shoulders on tie-rods by means of a high-speed air hammer rigidly mounted and fitted with proper dies. Left—Corner in the sand-blast room, where the metal parts are treated before going to the plating department. Right—Compressed air is used to fill tubular fuselage members with oil to prevent corrosion.



Airplane tires are quickly inflated with compressed air in the plant of the Boeing Airplane Company.

Type of mail 'plane built for United States service by the Boeing Airplane Company.



Radiators are tested with compressed air while being submerged in water. Escaping bubbles indicate leaks.

swaging and threading, the shoulder is punched in. By an older method this work was formerly done in a punch press, but it proved too slow. So a compressed air device was made. It consists of a high-speed air hammer, rigidly mounted and fitted with proper dies, which accomplishes the work much faster and better. One of our pictures shows this machine in action. The purpose of the squared shoulder is to make it possible to use a wrench on the tie-rod when adjustment is necessary.

One of the earliest uses of compressed air in our plant was for the cleaning of metal fittings after brazing, welding, or heat treatment. The sand-blast cabinet comes into play here. After welding, brazing, or heat treatment, the metal parts are first sand blasted so that all scale, which invariably forms in these operations, is removed before the part passes into the plating department for further treatment. Aluminum parts, which are finished by enameling, are sand blasted with fine sand and low air pressure to roughen up the surface so that a better enameling job may be done.

Steel parts are protected against corrosion by a coat of zinc plating and two coats of enamel baked on. After plating, the parts are dried in fine sawdust. When the drying is complete, any particles of sawdust that adhere to the surfaces are removed by a jet of compressed air. If the parts in question happen to be manufactured for the navy it is necessary to apply two coats of aluminum lacquer, and unless this lacquer is kept in motion the aluminum powder will sink to the bottom, leaving only the clear lacquer at the top of the container. By introducing a jet of compressed air, the mixture is continuously agitated so that no settling can occur.

The fastening of fittings in doing the major assembling is very often accomplished by riveting. To do this by hand methods would prove tedious and, in some cases, impossible. Here a light riveting hammer actuated by compressed air serves a very useful purpose, as can be seen by an accompanying illustration which shows a workman driving home a rivet in assembling a wing. One of the most useful small tools is the hand air drill. Much drilling must be done in finally assembling the parts, and for this work the air drill proves invaluable because the speed of the tool can be controlled by the operator. Air drills are rapidly replacing all other types of drills in our establishment.

Just before the final inspection of a major unit takes place it is necessary to remove all traces of dust, chips, or shavings—that is, to thoroughly clean it. This is readily accomplished by a vacuum cleaner actuated by a jet of compressed air. Another direction in which time is saved by the use of compressed air is in removing paints and enamels from drums; in inflating airplane tires; in testing radiators for leaks; in spray painting; in filling tubular fuselage members with oil to prevent their corrosion—in short, all the services performed by compressed air in the plant are too numerous to mention here. There are pneumatic devices in use that replace free-air blowers in blow-torch work, as well as special riveting ma-

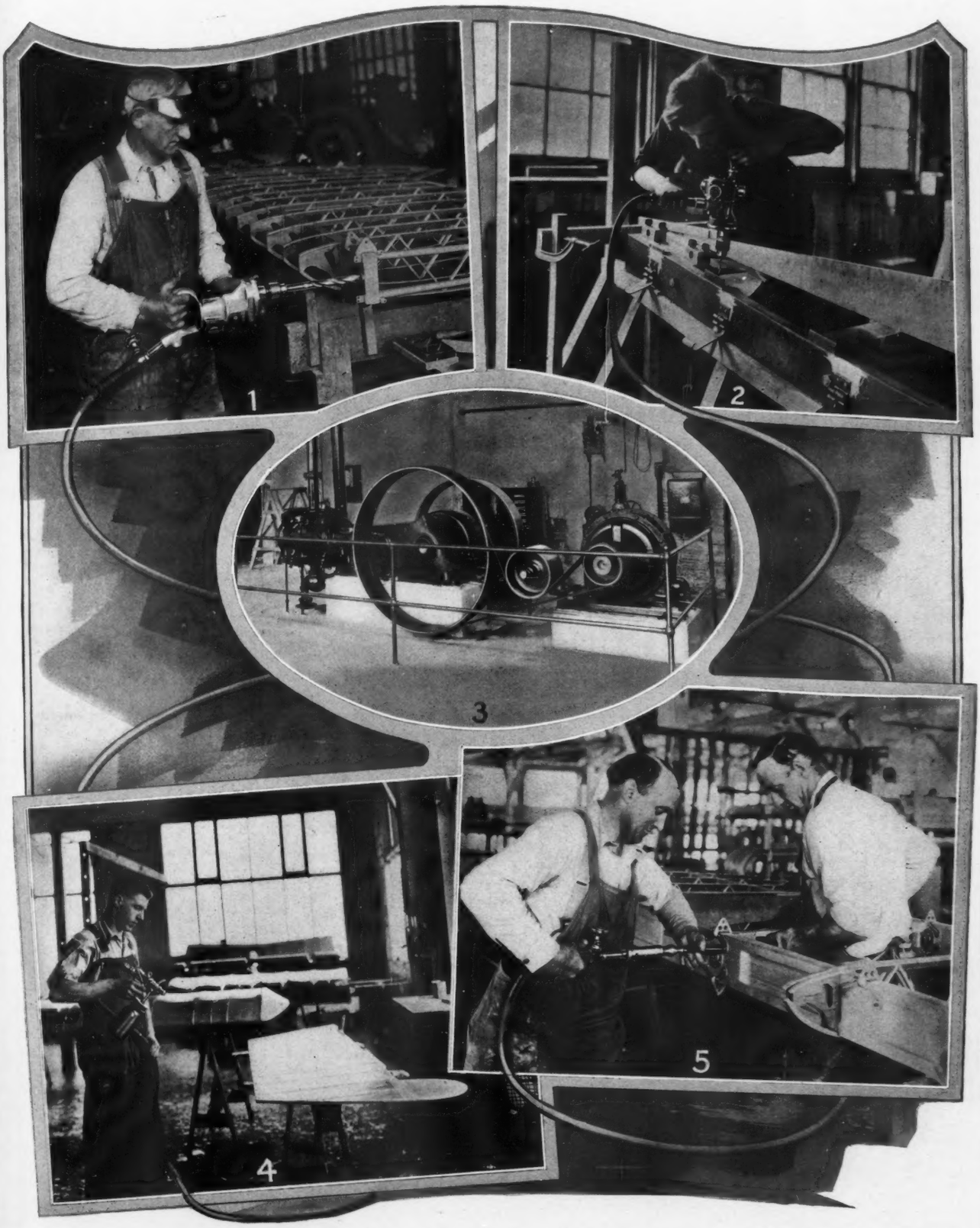


Fig. 1—Many parts go into the make-up of an airplane wing, and the work of assembling is facilitated by the use of air-driven drills.
Fig. 2—The handy air drill finds numerous services to perform in the plant of the Boeing Airplane Company.
Fig. 3.—Central compressor plant that furnishes the air used for manifold purposes throughout the different departments.
Fig. 4—Painting of airplane surfaces is done by means of the air brush.
Fig. 5—Light-weight pneumatic riveting hammers play an important part in wing-frame assembly.

chines for special work. It is a known fact that if our compressor plant and compressed air equipment should be rendered inoperative, it would entail serious delay if not complete shutdown. The possible uses of compressed air are very great and we are, therefore, continually trying to develop new apparatus designed to take advantage of its great flexibility.

The Boeing Airplane Company was incorporated in 1916. Prior to that time experimental work had been carried on with seaplanes, but in 1916 the company undertook the designing and the building of a two-seater airplane suitable for use as a naval training machine. Two 'planes were constructed and submitted to the navy for approval. The result of these tests, which were carried out in Pensacola, Fla., was a contract for 50 of this particular type of training 'plane. From this beginning has developed the present company which boasts adequate shop facilities and a personnel that can design and construct all types of modern heavier-than-air craft. Some 400-odd people are now employed in the plant.

The company has produced all types of aircraft, varying from training 'planes to special high-speed pursuit 'planes. Armored airplanes have been built weighing, ready for flight, in the neighborhood of five tons. Since the World War the Boeing Airplane Company has built approximately 50 per cent. of all military aircraft produced in American-owned-and-operated factories, and is today the largest aircraft factory west of the Mississippi River.

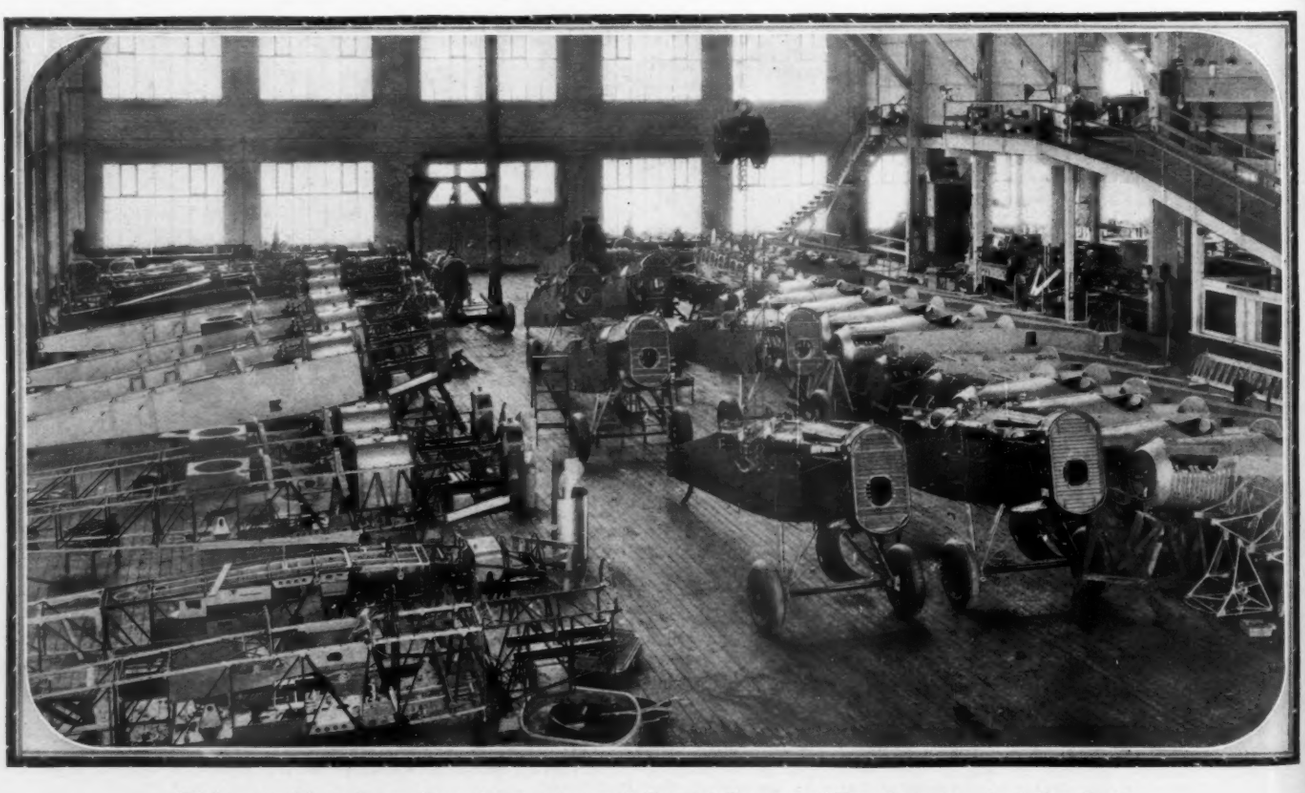
This seaplane, known as the "PB-1," was constructed by the Boeing Airplane Company for the Pacific-Hawaiian flight.

EARLY ROCK BLASTING

THE *British Quarry Managers' Journal* reproduces an entry in the register of the Parish of Breage, Cornwall, the most interesting mining county in England, showing that rock blasting was employed there 250 years ago, although nothing is said of the rock drilling which must have accompanied it. The wording of the register is as follows: "Thomas Epsley Senior, of Chilchampton p'sh of Bath and Wells in Somersetshire; he was the man that brought that rare invention of shooting the rocks, which came here in June, 1689, and he died at the Ha and was buried at Brea the 16th day of Dec. in the Yeare of Our Lor Christ 1689."

ECONOMICAL LOW-POWER DIESEL IN FRANCE

THE first low-power Diesel motor in France has recently appeared, a product of the French Société Anonyme l'Aster. The new motor is of 10 H.P., and the fuel consumption is guaranteed to be less than 0.22 kilo (under half a pound) per horsepower-hour. The fuel cost is given as 0.15 franc per horsepower-hour, as compared with 0.4 franc in the case of a common gasoline motor.

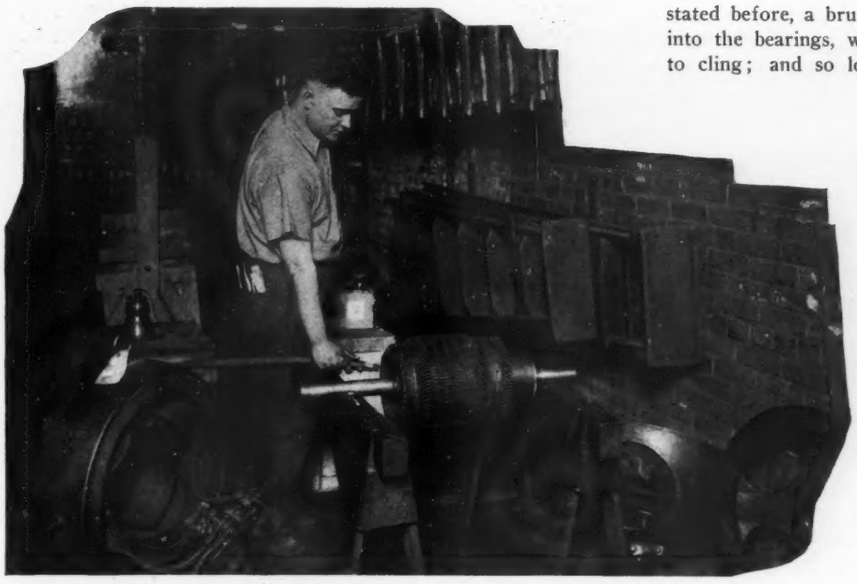


Flying machines in various stages of completion in the assembling department of the plant.

Compressed Air Highly Effective for Cleaning Parts of Electric Motors

By G. T. MACFARLAND*

THE USE of compressed air in the cleaning of parts during automotive electrical repairs is recognized as an absolute necessity if the job is to be accomplished properly. Experience of over twenty years in automotive repairs has taught the writer that proper cleaning cannot be assured by any other method. The use of a cleaning pan and brush with either kerosene or gasoline is not only slow, obsolete, and inefficient, but costly.



Compressed air is the most effective penetrative agency for cleaning the complicated windings of an armature.

In making electrical repairs a thorough removal of all grease and dirt is essential if a lasting job is to be done. The brush, while removing visible accumulations of dirt, is bound to force a part of it into all crevices and between the strands of wire in the coil. If it is left there it may be the cause of either an electrical or a mechanical breakdown.

All deposits inside an electrical unit after it has been in use carry small particles of metal, carbon, and road dirt, and may even include metal chips and filings carelessly allowed to be deposited there by the repairman. The effect of metal or carbon deposits between field coils and frame or between armature coils and cores is obvious. They often cause short circuits, eddy currents, and other factors of inefficiency, and can only be positively removed by the use of compressed air both as a means of spraying cleaning fluid to loosen the foreign matter and to eliminate it and of drying out the part after washing.

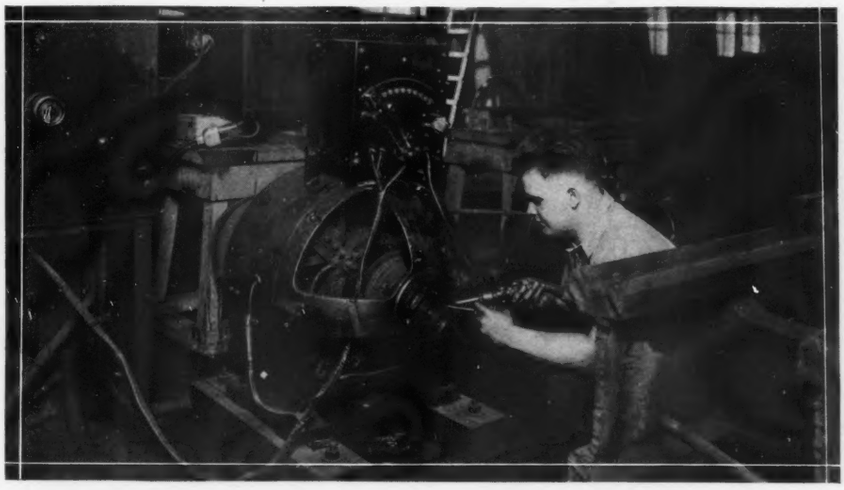
For instance, one of the most difficult mechanical jobs on an electrical unit is the proper cleaning and inspection of bearings. In the case of plain bronze bearings, particularly when fitted with oil grooves, the brush method is absolutely useless, as such bearings are so small that the grooves cannot be reached by a brush. In fact, the brush deposits rather than eliminates residue from the cleaning fluid. But the air-nozzle gets it all. It really cleans.

Ball bearings are particularly hard to clean sufficiently to learn by inspection whether they are still perfect or should be replaced. As stated before, a brush forces particles of dirt into the bearings, where they are very liable to cling; and so long as there is either oil or cleaning fluid in the bearing it may appear on examination to be in good condition, while, if it were perfectly dry, a defective ball or a chipped race might easily be detected.

If the bearing is placed in a cleaning tray, which is certain to have sediment in the bottom, it is bound to stir up this sediment and move it around, and some of it will get inside the bearing. With cleaning fluid under air pressure, not only is the cleaning fluid forced completely through the bearing at high pressure but, by using the air alone after washing, all surplus fluid as well as particles of dirt are bound to be removed. After inspection, the bearings should always be dipped in a bath of clean oil, letting the surplus oil drain off as a safety measure against the formation of dust and from the moisture that may be carried in by the air. Ball-bearing manufacturers tell us that a very large percentage of ball-bearing trouble is caused by improper cleaning of the bearings when making repairs.

From a point of economy, the use of the air-pressure cleaning method is far in advance of any other. Not only can a thorough cleaning job be done in less than one-tenth the time required by any other method, but it is the only method by which a real job can be done.

The equipment necessary is not expensive and complete units may be obtained. Installation costs but little.



Cleaning ball bearings of an electric motor with a solution sprayed by means of compressed air.

*Manager Automotive Electric Service Association.

Reprinted by courtesy of Automotive Electricity.

SPRAYING CRANBERRY BOGS FROM ALOFT

TURKEY and cranberry sauce are so closely associated in the minds of the American people that Thanksgiving dinner without one or the other would be incomplete. Therefore, to prevent what would have been nothing short of a national calamity, cranberry growers in the East recently took a leaf out of the cotton planters' book by "dusting" or spraying their bogs from aloft to save this season's crop. In the case of the cotton fields, the airplane attacks with insecticide were directed against the destructive boll weevil; but, in this instance, clouds of poisonous chemicals were scattered by the flying machine for the purpose of stamping out "rot disease."

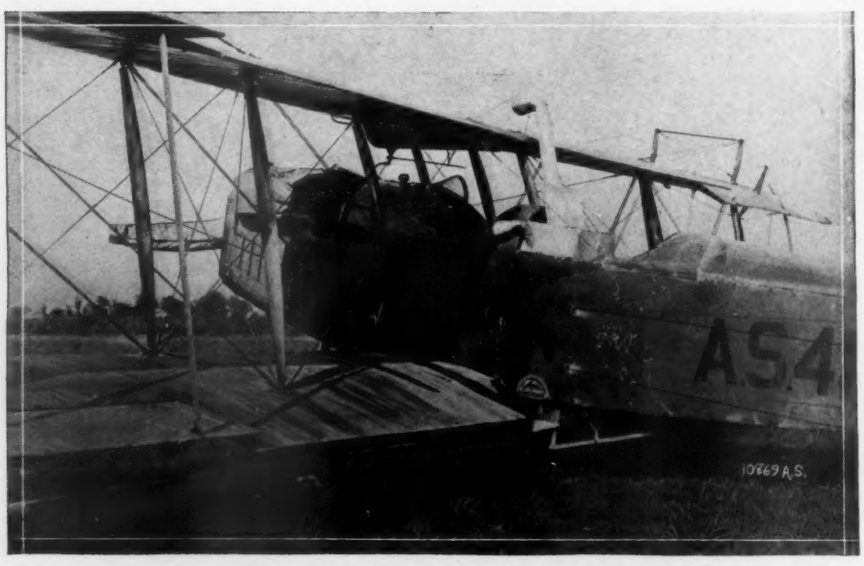
The airplane used was a standard Curtiss machine suitably equipped with a hopper or container for the chemical, a copper sulphate compound. In flight, the powder is discharged from the hopper by a slight pressure of the aviator's foot, and this action simultaneously functions a spray or atomizer which scatters the substance in the wake of the 'plane.

To do this work of spraying effectually, the machine must fly at an altitude not exceeding 25 feet from the ground. The chemical can then be placed with remarkable accuracy and is not carried hither and thither, as might be imagined. As a matter of fact, "an astonishing amount of the poison," so we are informed by B. R. Coad, entomologist of the United States Department of Agriculture, "adheres to the plants over a very wide path under atmospheric conditions that would make it absolutely impossible for a ground dusting machine to successfully treat the plants. The exact cause of this adhesion can only be guessed at; but, judging from observations which have been made of the efficiency of different types of ground machines, with varying velocities of air blast, it seems quite likely that this remarkable result is due to the tremendous blast of the propeller."

Dusting 'plane flying about 25 feet above the area to be powdered with the disease-killing chemical.

As far as area covered in a given time is concerned, the airplane, of course, far outstrips any other system of spraying yet devised. It has been said that by the use of hand method one man can cover an acre of cranberry plants in a day, while a flying machine can "dust" 500 acres in that time. At that rate, an airplane can do the work of 5 men!

Just what is the cost for this service has not been made known; but we learn that a commercial aviator, spraying a poisonous chemical over cotton fields in Corpus Christi, Tex., charged fifteen cents an acre, or $69 to dust a 460-acre tract. The job was finished in three hours.



Close-up of an airplane equipped with dusting apparatus. The lever that opens the discharge end of the hopper is visible just below the fuselage.

ALL-WESTERN ROAD SHOW

ALL ROADS will lead to San Francisco, Calif., during the week beginning November 9. One of the outstanding events of the year in roadbuilding and allied activities in the United States takes place at that time at the All-Western Road Show.

Numerous conventions from the Pacific Coast, the Northwest, and the Rocky Mountain States are expected to bring about 10,000 visitors to the show; and, as each convention is arranging a separate program, much is promised the visitor in the way of instruction and entertainment. For the sake of those interested, the week's program is given:

Nov. 9—Annual Convention of the Western Association of State Highway Officials.
Nov. 10—Good Roads' Day.
Nov. 11—Road Commissioners' and Supervisors' Day.
Nov. 12—Contractors' Day.
Nov. 13—Annual Convention of the Pacific Sand & Gravel Association.
Nov. 14—Annual Convention of the Western Construction Equipment Distributors.

As reservations for space at the show soon exceeded 125,000 square feet, and as no building in San Francisco was large enough to house the exposition, it was found necessary to make it an out-of-door show. The ground selected—25 acres—are on the site of the 1915 Panama-Pacific Exposition; and arrangements have been made to take care of the exhibits in five huge tents. Each of these tents is more than 300 feet long; and, for the convenience of visitors, the various makes of machinery of the same classification will be displayed in close proximity. The conventions will be held in a frame building, erected on the show grounds, which is large enough to accommodate 2,000 persons.

There will be rock, sand, and gravel-handling equipment and machinery of many kinds together with several working outfits of dragglines, crushers, and compressors. These will be displayed inside the tents and within the demonstrating area outside. Rock-product men from every section of the West will be in attendance; and the speeches and discussions forming part of the program will refer to the problems peculiar to the West. This phase of the show should be of much value to all attending groups.

Rapid Progress on Broad Street Subway in Philadelphia

The Manner in Which the Keystone State Construction Company Has Handled Its Part of the Work Presents Many Interesting Aspects

PART II

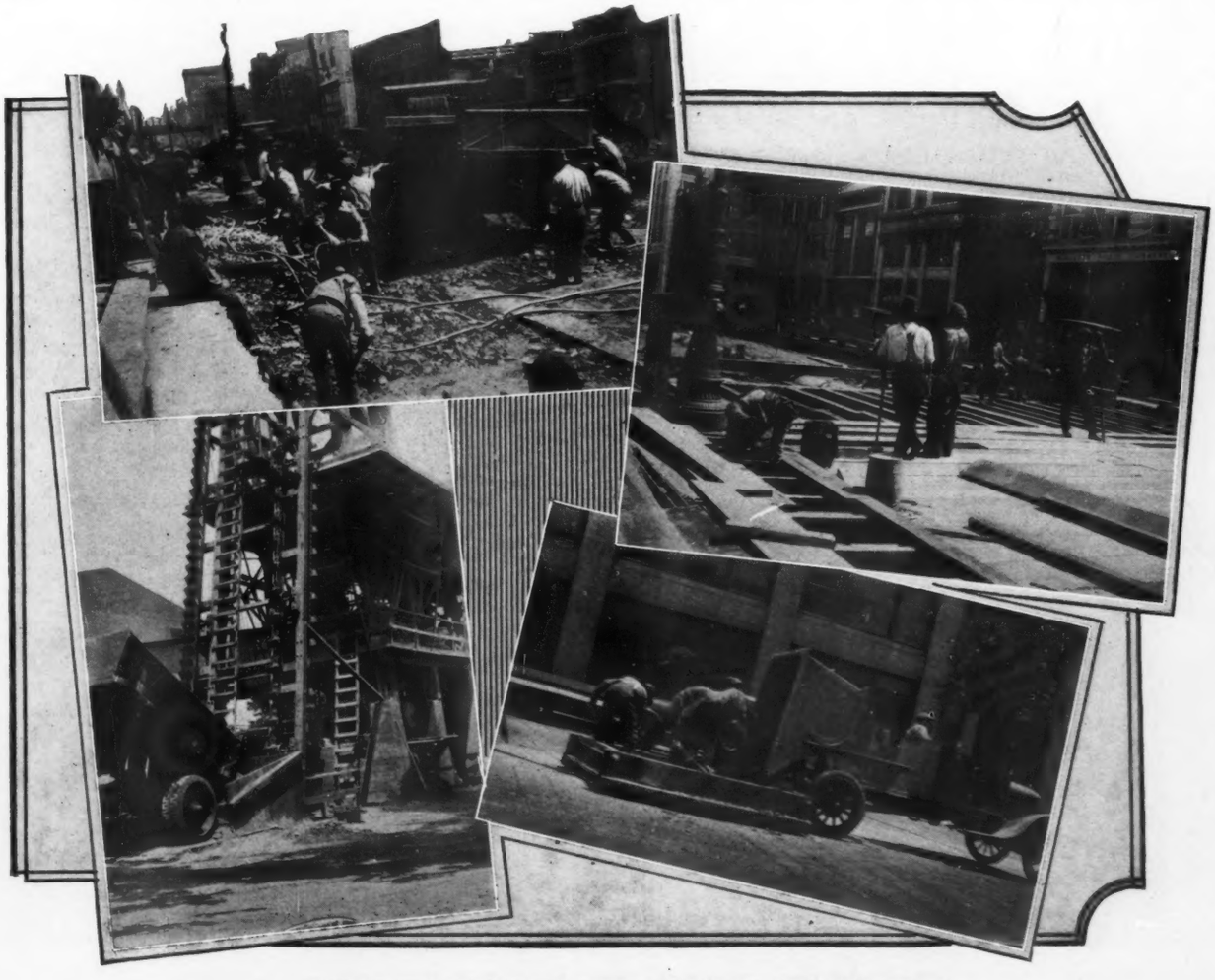
By ROBERT G. SKERRETT

WORK ON the Broad Street Subway north of City Hall in Philadelphia is covered by four major contracts which are about equally divided between two nationally known contracting concerns of ripe experience in undertakings of this character. For the sake of convenience, we shall treat in separate installments of the activities of the two contractors. Indeed, it would be confusing to do otherwise, because each contractor has elected to pursue a different course in carrying out certain important phases of his task.

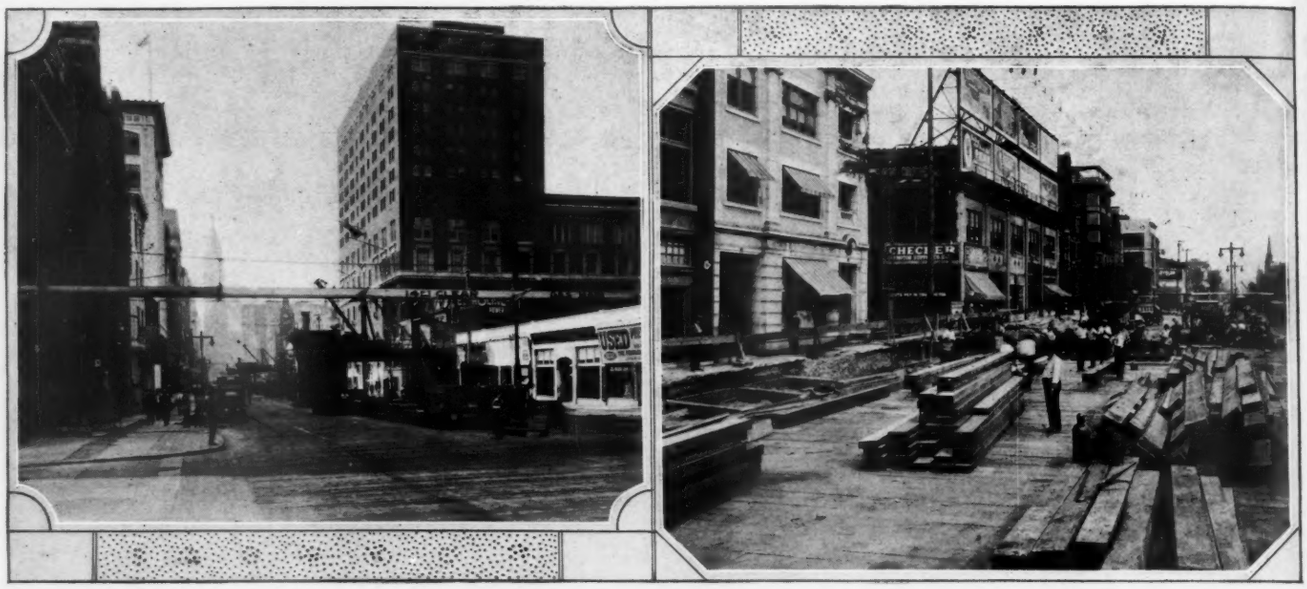
On June 9, 1924, bids were asked on the section of the Broad Street Subway lying between Stiles Street and Clearfield Street. This section covers a distance of 10,131 feet and represents nearly one-third of the project. Bids were opened on July 15, 1924, and two days later associate contracts—officially known as Contract 105-A and Contract 105-B—were awarded, involving an outlay of $14,215,100. The successful bidder was the Keystone State Construction Company; and the date of completion was given as January 31, 1927.

Besides requiring the construction of nearly two miles of 4-track subway and the building of three stations—which has necessitated excavating from building line to building line, the contracts called for considerable underpinning of buildings on either side of Broad Street, the underpinning of tracks of the Reading Railway Company and of a highway bridge which crosses those tracks near Lehigh Avenue, together with the reconstructing at a lower grade of substantially 1,765 linear feet of trunk sewers and 15,000 feet of small sewers, the laying of 14,800 linear feet of big water mains, and the removing of the old 30-inch and 48-inch water mains lying in Broad Street in the way of the subway.

Sewer reconstruction and water-line relocation work was in hand by August 15, following; and the beginning of work in Broad Street proper was formally inaugurated, with appropriate exercises, by the mayor of Philadelphia on August 25, 1924. Since that date decidedly rapid progress has been made; and success in this respect has been in no small part due to some of the labor-lightening mechanical facilities employed by the progressive contracting company.



Various surface phases of work on the Broad Street Subway.



**Left—Looking south on Broad Street at the intersection of Callowhill Street with the tower of City Hall in the distance.
Right—Breaking the surface and laying the decking where Grand Avenue crosses Broad Street. Despite seeming confusion, traffic moves unimpeded on half the street.**

Aside from requiring the complete removal of the surface asphalt and the underlying concrete foundation of Broad Street, which is 69 feet from curb to curb, the contract called for carrying the subway excavation to an average depth of 25 feet and to a maximum depth of 43 feet where the subway underruns the previously mentioned railroad tracks. All told, the job has comprehended the removal of 785,000 cubic yards of material—including work on sewers and underpinning operations. Approximately 50 per cent. of the excavated material has consisted of soft mica schist—the remainder being mostly clay. Both the digging of the clay and the excavating of the schist have been done in the main by air-driven tools—that is to say, by pneumatic clay diggers and by "Jackhamers" of a puff-blowing type especially designed to meet the exacting conditions imposed. Without this blowing feature it would have been difficult, if not impossible, to get rid of the cuttings fast enough to prevent them from clogging the bits.

Fully alive to the obstacles to be overcome, the Keystone State Construction Company instituted competitive tests in order to ascertain what type of rock drill would best answer in getting out the schist. The type of "Jackhamer" chosen for the work was the Ingersoll-Rand Company's BBRA-13 drill—their regular BBR-13 drill modified to insure the needful blowing action. For the sake of those likely to be interested in this phase of the matter, the following details are mentioned:

The BBRA-13, with operating air at a pressure of 80 pounds, uses the equivalent of 81 cubic feet of free air per minute when running as a blowing drill. This is 15 cubic feet more a minute than is required by the standard BBR-13 when running dry—indicating that the blowing requirements call for the expenditure of 15 cubic feet of air per minute. The trials brought out that the drill would give the best results when equipped with 4-point steels. When fitted with 4-point, 14 and 5 degree bits, and driven with air at a pressure of 80 pounds, the BBRA-13 drilled a hole ranging from 2 inches down to 1½ inches in diameter to a depth of 10 feet in only 7½ minutes. A competing, continuous-blowing type of drill took 11 minutes to drill a hole of similar size to a depth of 9½ feet, and consumed 100 cubic feet of air a minute. The differences in performance can be readily evaluated by anyone familiar with work of this sort.

The preliminary work of removing the asphalt and the supporting concrete was done with the aid of paving breakers operated by air furnished by a suitable number of portable compressors. Subsequently, similar paving breakers—known as Type CC-25—were utilized advantageously at the headings of the excavation where they were employed to trim such of the mica schist as was too soft to drill and yet too hard for the pneumatic clay diggers to dispose of. The clay diggers generally used on the job, and found fully equal to the work expected of them, were what is known as Type 56-H. For certain work, air-driven

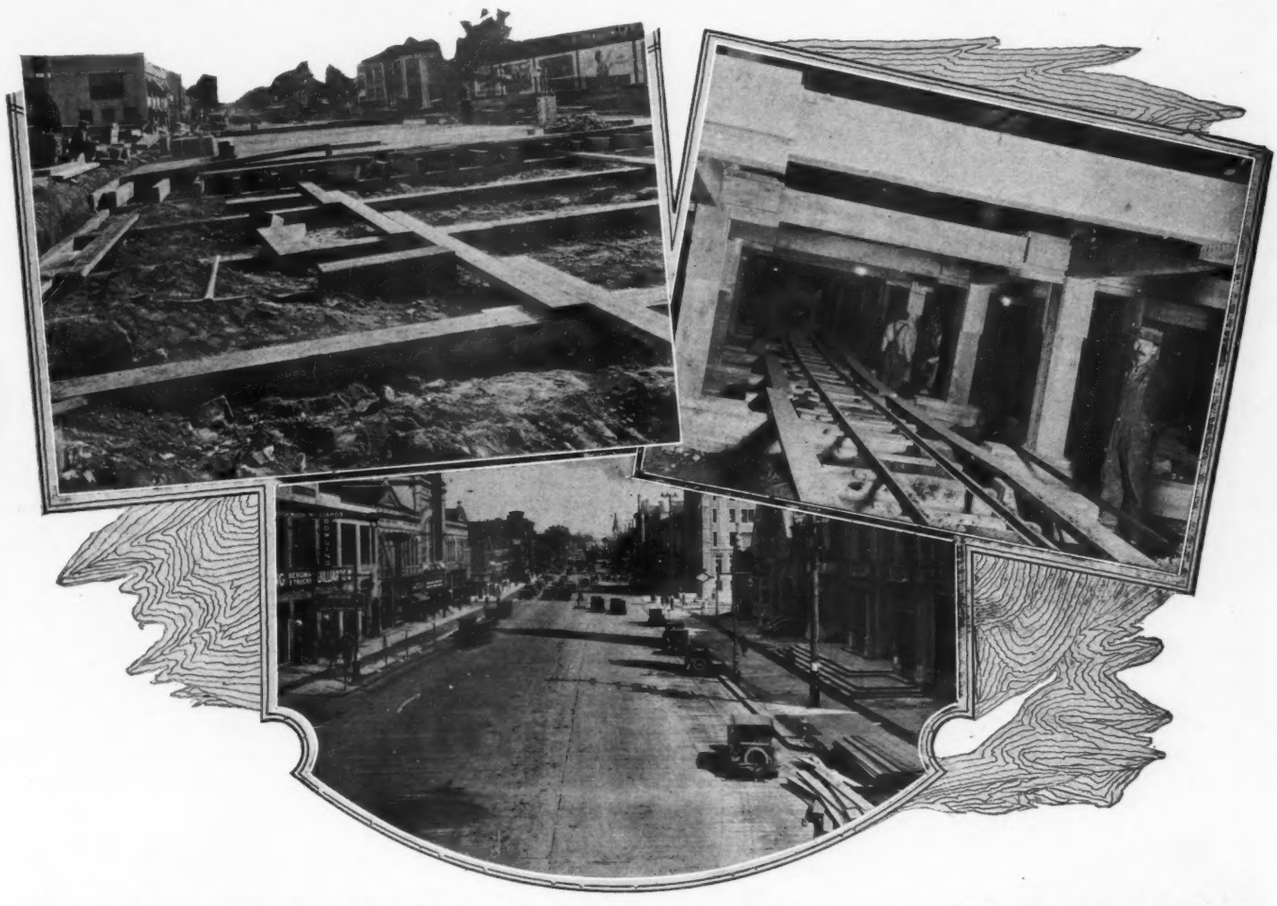
**Left—Head frame at one of the fifteen shafts on Broad Street.
Right—Traffic being diverted while first half of decking is being placed.**

trench diggers of the 156-H type were employed.

With the removal of the paving completed and with the starting of the subway digging, all air-driven tools were supplied with motive air from lines leading from a central compressor plant located conveniently on Broad Street near Lehigh Avenue. This plant contains four air compressors of Ingersoll-Rand make, equipped with 5-step clearance control, each of which is driven by General Electric motors of 213 H.P. Each compressor is rated at 1,302 cubic feet of air per minute at a pressure of 100 pounds. The plant is provided with two No. 7 vertical VK aftercoolers, also

cavating, for a trifle more than half the width of the street, to a general depth of 2½ feet. This provided vertical space in which to place the woodwork forming the decking and its immediate support. In the shallow trench were laid crosswise on the ground the top sets of 12x12-inch timbers; upon these timbers were next set up, parallel with the line of the street, stringers of 5x12-inch stuff; and, finally, at right angles to and on the stringers, was laid the decking of 5-inch planking. As soon as such a section of decking was in place traffic was diverted over it, and then the adjacent half of the street was similarly excavated and decked. In this manner the entire roadway

width of the street; and the top-set timbers have been promptly supported, as the work went forward and spread laterally, by 12x12-inch posts. The top lifts have had an average depth of about seven feet, while the bottom lift has varied in accordance with the final or track grade. The timbering procedure has been very much like that employed in square-set stoping in mining operations. The dimensions shown by one of our drawings, as well as certain of the photographs, indicate the strength of the timbering. This has been necessary to insure stability when supporting the greatest volume of traffic moving at normal permissible speed.



Left—First step employed by the Keystone State Construction Company in decking over a half section of Broad Street. Right—Heavy underpinning after the excavating had reached a depth calling for two lifts immediately beneath the decking. Bottom—Broad Street completely decked over where the Keystone State Construction Company is carrying on subway work.

built by the Ingersoll-Rand Company. Air from this station has been delivered to all parts of the 10,000-foot subway section at a working pressure of not less than 90 pounds. The air, besides driving excavating tools, has served to operate a number of "Little Tugger" hoists, some woodborers, and certain of the equipment in the busy blacksmith shop—among which might be mentioned a "Leyner" sharpener, a No. 25 oil furnace, and a No. 8 grinder.

Excavating has been carried on by the familiar cut-and-cover method and in such a way as to interfere to the least practicable extent with vehicular traffic. The procedure is made clear by some of the accompanying illustrations. The first step consisted of surface ex-

width of Broad Street, from end to end of the portion embraced by Contracts Nos. 105-A and 105-B, was covered over.

During the progress of the decking, shaft-head frames were constructed at intervals ranging from approximately 450 feet to 815 feet apart. All told, 15 of these shaft-head frames were built, and each was provided with a 40-H.P. electric hoist. Shafts were sunk from these strategic points; and from every shaft two headings were driven—one north and one south.

The excavating of the major part of the subway has been advanced by a series of minor operations from which the cut has been progressively widened so as to embrace the whole

Wherever rock has been encountered only short sections of the face have been shot down at a time. The muck has been loaded by hand and hauled to the shafts by storage-battery locomotives. The buckets, each of which has a capacity of about 1⅓ yards, are successively hoisted from the cars to the head frames where they are dumped into hoppers and hauled away by motor trucks. The decomposed mica schist has been effectually trimmed with clay diggers, and two of these air-driven tools have been able to keep four buckets busy at a heading. The muck-handling equipment has consisted of 21 storage-battery locomotives of from 2 to 4 tons capacity, of 108 buckets, and of 108 flat cars

Left—"Jackhamer" being used to drill holes in concrete footings for drift bolts to secure steel columns.
Right—Paving breakers have done effective work in trimming the soft mica schist extensively encountered in excavating for the subway.

The work was carried on in two shifts of ten hours each.

Some idea of the amount of lumber used on the 10,000-foot section can be gathered from the fact that all phases of the work have required a total of 13,000,000 board feet; and of this, 3,450,000 feet have gone into the decking and 1,500,000 feet into the stringers directly beneath. The remainder of the lumber has been utilized in the underlying timbering, the square sets of which have been spaced longitudinally eleven feet apart on centers.

In underpinning the bridge over the tracks of the Reading Railway Company, the principal problem was that of providing ample support for the bridge abutments. The procedure of underpinning the abutments consisted of sinking a series of shafts in each of which a column was placed and then of setting upon these columns steel girders designed to bear the loads. After the shafts were sunk, trenching was done from the track level—one track at a time, and next the girders were moved into place. The subway section—at this point a tunnel—was subsequently excavated beneath the girders. The rock was there found soft enough to be broken away with clay diggers.

Before it is finished, the 10,000-foot section will call for the placing of 90,000 cubic yards of concrete. So far, there has been placed daily a maximum of 850 cubic yards. This concrete is mixed at a central plant equipped with two 1-yard mixers and an auxiliary mixer on the street. The concrete is carried from the mixer by trucks provided with Easton dump bodies, and each truck handles one cubic yard at a time. From the mixer to the southernmost end of the job, the trucks have to transport the concrete a distance of two miles through traffic, and one may naturally wonder whether or not this delay would induce troublesome segregation of the mix. The answer is, no, because the concrete has added to it 4 pounds of "Cellite" for each 100 pounds of cement. Cellite contains a diatomaceous earth pulverized to such fineness that it will pass through a 2,000-mesh screen. The action of Cellite prevents the water from rising to the top of a mix and

Left—Resurfacing a section of Broad Street beneath which the subway is finished.
Right—Central concrete mixer plant which is equipped with two 1-yard mixers.

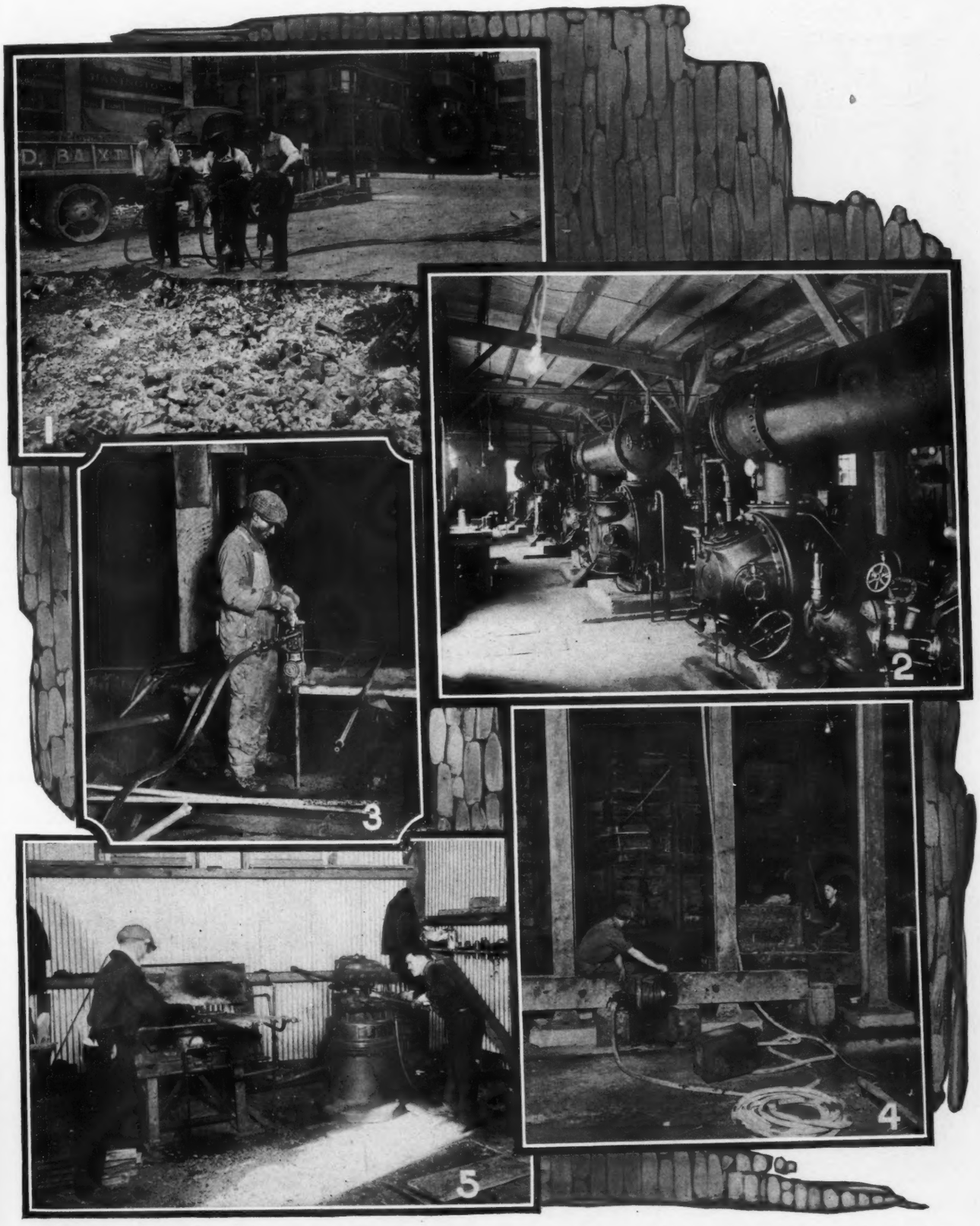
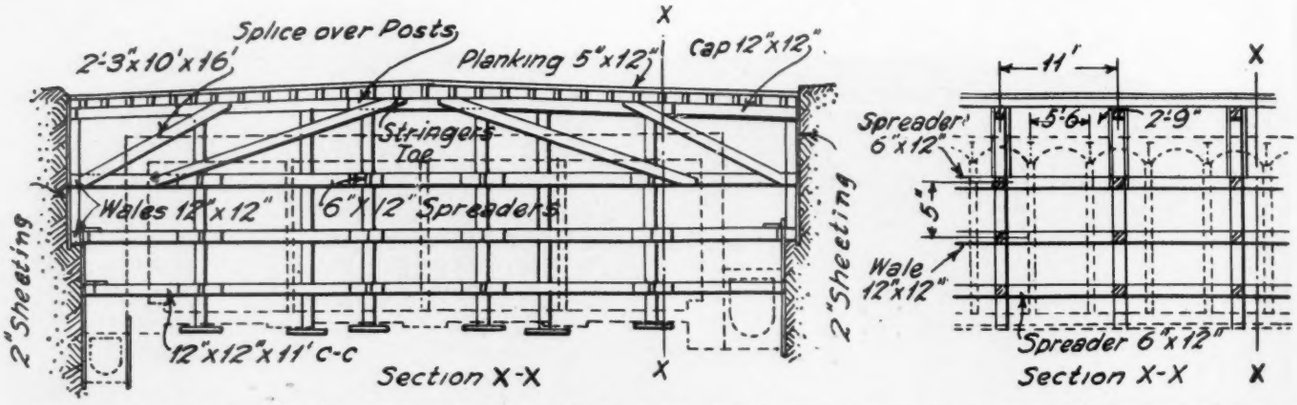


Fig. 1—The first step in building the subway consists of clearing away the street surface with air-driven paving breakers.
Fig. 2—One of the two compressor plants, equipped with big "PRE-2" machines, which furnish air to the different sections of the Keystone State Construction Company's work on Broad Street.
Fig. 3—"Jackhamers" drilling 10-foot holes in the rock encountered in excavating for the subway.
Fig. 4—"Little Tugger" hoists have proved very helpful in handling the forms employed in the concreting work.
Fig. 5—The oil-fired furnace and the "Leyner" sharpener have done much to aid the blacksmiths in keeping all the drill steels in proper condition.



Method of timbering employed by the Keystone State Construction Company in supporting the decking while carrying the excavation deeper and deeper.

makes the concrete homogeneous and easy flowing. This increased workability is especially valuable where the reinforcing steel is set close and where it is doubly important that the mixture should fill in snugly. The concrete is delivered to points underground through square openings cut in the decking at convenient intervals; and the material is placed entirely by gravity and without tamping. Spades are used only to pull the coarse aggregate away from the faces of forms.

The footings for the steel columns of the finished subway structure are first poured, and then the columns are placed, lined up, and finally riveted to the beams which are set upon them. Incidentally, it might be mentioned, that there will be 10,000 tons of steel in this 10,000-foot section of the subway. Drift holes for the steel columns are drilled in the footings with "Jackhamers." With the overhead beams in position, the deck load is transferred to the steel structure and the timbering removed. After the timbering is out of the way the side walls are poured. Blaw-Knox collapsible forms are used for the side walls; and the form sections are lifted into approximate position by means of "Little Tugger" hoists. When at the desired height, the forms are shoved into exact place by the workers and secured by the expanding action of turnbuckles.

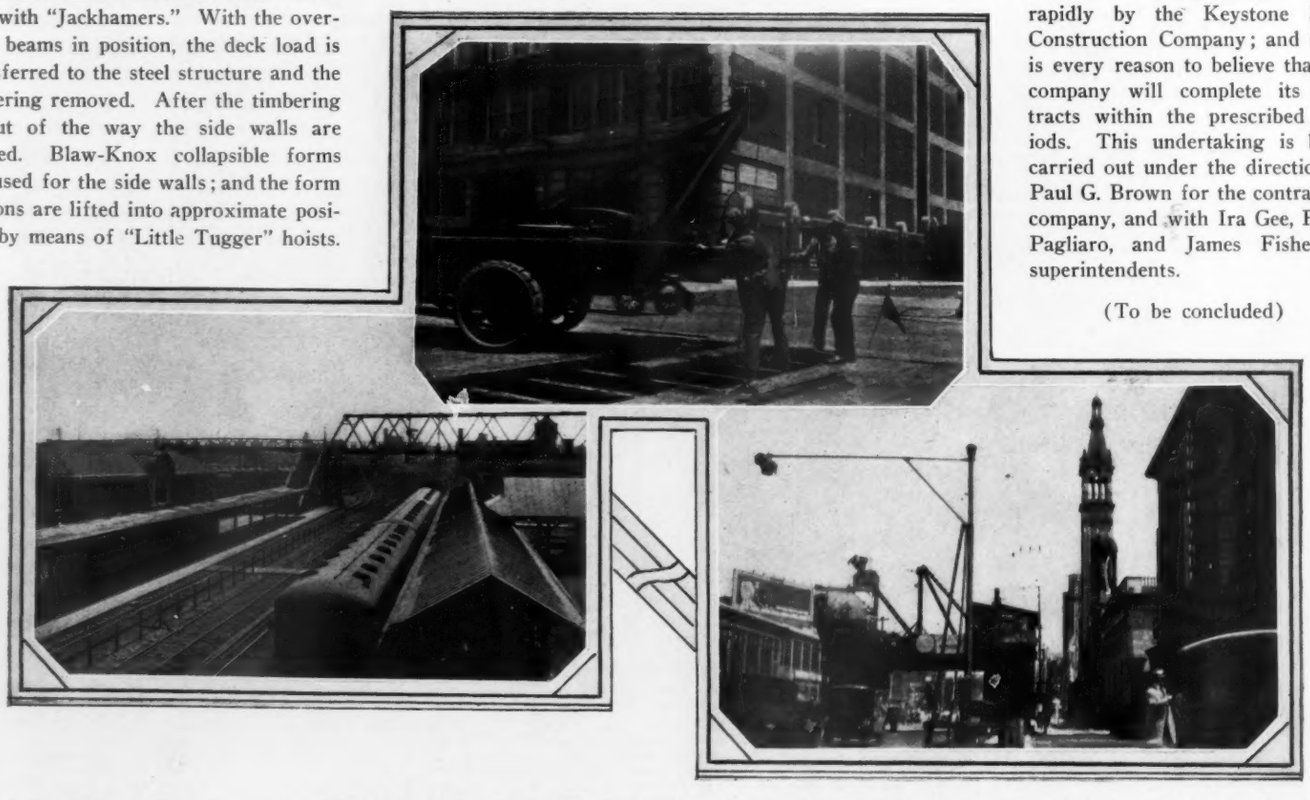
The next operation is that of pouring the floor; and then comes the pouring of the roof. The roof forms are moved into position on travelers carried on rails, and the travelers are pulled by "Little Tugger" hoists. Chain blocks on the travelers shift the form sections vertically when lowering or raising them either when removing the forms or when lifting them into casting position.

At three points, large sewers cross beneath the floor of the subway. Two of the sewers had to be depressed—one of them three feet and the other nineteen feet, while the third sewer was disposed of by changing its sectional form.

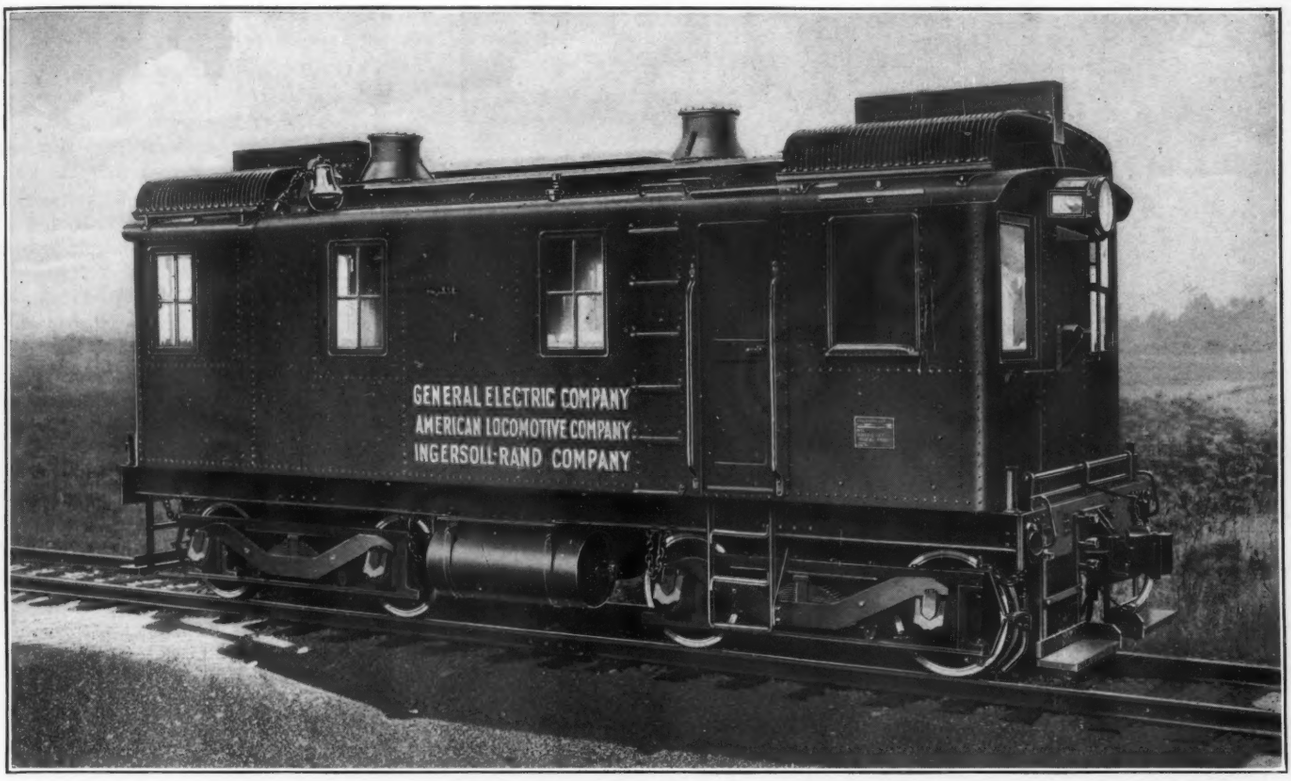
After the opening of bids on March 17, 1925, Contract No. 110 was awarded the Keystone State Construction Company. This contract continues the work of the company southward to Filbert Street, immediately north of City Hall, and will entail a municipal expenditure of $17,700,000. The section is 7,000 feet long and will involve a total of 768,000 cubic yards of excavating. According to exploratory drillings, the contractor will be obliged to remove only about 10 per cent. of rock—the remainder of the ground being composed of clay. It is estimated that 117,000 cubic yards of concrete will be placed within this stretch of the subway. The method of operating on this section will be essentially like that employed under Contracts Nos. 105-A and 105-B.

Work is being pushed along rapidly by the Keystone State Construction Company; and there is every reason to believe that the company will complete its contracts within the prescribed periods. This undertaking is being carried out under the direction of Paul G. Brown for the contracting company, and with Ira Gee, Philip Pagliaro, and James Fisher as superintendents.

(To be concluded)



Top—Lifting out posts and other supporting timbers after the load of the decking has been transferred to the finished steelwork underneath.
Left—Tracks of the Reading Railroad beneath which the subway has been driven.
Right—Head frame at Shaft No. 4 is typical of all the other head frames.



OIL-ELECTRIC LOCOMOTIVE WINS MERITED RECOGNITION

On September 28, the Central Railroad of New Jersey marked an epoch in railway engineering by ordering the first oil-electric locomotive to be put in regular service on any line in the United States. The locomotive in question, a 60-ton unit, will be used by the Central Railroad of New Jersey for work in one of its Metropolitan terminals. This locomotive is the outcome of the joint efforts of the American Locomotive, the General Electric, and the Ingersoll-Rand companies. The initial locomotive of this type has been in continuous service fully nineteen months and has been actively engaged in demonstrating its distinctive merits on a number of big eastern railroads.

On October 2, the Long Island Railroad Company purchased from the same associated builders a 100-ton oil-electric locomotive which that railroad will use at its Bushwick Terminal in Brooklyn, N. Y. Neither of these purchases was made until the responsible officials concerned had thoroughly satisfied themselves that the oil-electric locomotive was deserving of recognition and that it promised to make possible very large operating economies.

Railway executives and the engineering fraternity at large will follow closely the performances of these locomotives, which can be built to do any work that any other type of locomotive can do—that is to say, they can be built for passenger, freight, or switching service.

SUCTION CLEANER FOR RAILROAD TRACKS

AN INTERESTING suction apparatus has been developed recently by the Pennsylvania Railroad for cleaning its tracks. The device consists of a flat car pushed ahead of a locomotive, which also supplies steam for the suction operation.

From a raised framework on the car extend backward and downward, at an angle of about 45 degrees, seven flexibly connected 8-inch suction pipes having their open ends as close to the track as possible. Five of these tubes are inside the rails and two outside. The suction pipes are connected to other horizontal pipes which are placed overhead and which extend forward, emptying into a coal car or other dumping receptacle. A steam pipe, with a 11/16-inch nozzle, discharges steam at a pressure of 150 to 175 pounds into each of the pipes—producing an effective vacuum and driving forward and out all the refuse collected. The flexible connections permit the pipes to be raised or lowered, as circumstances may require. This is done by pneumatic devices that draw on the air-brake system for power.

NOT MUCH OF A PARADOX

PROFESSOR Irving P. Church, in *Sibley Journal of Engineering,* states that a vehicle may be moved directly against the wind by means of a windwheel actuated by the same wind. A number of scientists and engineers state positively that such a vehicle would be a mechanical paradox, and that it would not work. But paradoxes do work, and that constitutes the paradox. Professor Church claims that he has constructed a model and that it does work.

A simple arrangement rises before our mind's eye at once: a light 4-wheeled truck on a railroad track, with a worm wheel mounted on the middle of the forward axle. Then there is a horizontal shaft, mounted in bearings on the truck and paralleling the track, with a worm upon it in proper mesh with the worm gear, together with a large windwheel on the front end. We assume, of course, that it is arranged to turn the gear and axle in the desired direction, and then we do not need to be told that the car will be driven toward the wind. However, we are not disposed to assert that the power so developed would be of any practical value.

USING MORE FUEL TO USE LESS FUEL

TESTS are in progress at the United States Bureau of Standards to determine the influence of different factors upon the starting of internal-combustion engines. Measurements are made both of the time required to start such an engine and of the amount of fuel used. In many of these experiments various fuel-air ratios have been employed, and the results show that it generally requires a longer time to start with lean mixtures than it does with rich ones.

The fact that the engine, with lean mixtures, fires after it has made several revolutions indicates that the mixture in the engine cylinder becomes richer after each revolution, although the mixture delivered by the carbureter remains the same. What is of particular interest, however, is that with the very lean mixtures the total quantity of fuel entering the engine before an explosion is obtained is greater than when richer mixtures are employed, and that the engine fires after fewer revolutions. In other words, within certain limits, using more fuel per revolution makes it possible to start the engine with a smaller total quantity of fuel.

A portable compressor provided the motive air for operating the cement gun used in forming the reinforced-concrete walls.

Here we see how the gunite walls appeared during various stages of their construction.

Close-up of the gunite process showing how the concrete was shot against the reinforcing metal backed by a wooden form.

SHOOTING CONCRETE WALLS INTO PLACE

"BLOWN up in a constructive way." In these words the *Buffalo Evening News* has described the erection of a building for the R. S. McManus Structural Steel Company of that city. Contradictory as the statement may sound it is, nevertheless, quite true, as The Paragon Gunite Corporation has literally "blown up" the walls. To make a long story short, the structure has been reared by the gunite process—concrete shot in place by means of compressed air. In this way approximately 6,000 square feet of concrete wall, 2 inches thick, have been built in record time. Air for this purpose was furnished by a 9x8-inch Type Twenty portable compressor.

It can readily be appreciated that one workman using the gunite method can place much more concrete in a given time than a gang of men pouring the material in the ordinary way. Furthermore, as an accompanying illustration plainly shows, the gunite process does away with the usual form of mold. Instead, the concrete is shot against a metal latticework—the only form necessary being a removable one placed against but one side of the wall at a time.

UNDERGROUND FREIGHT LINE PROPOSED FOR LONDON

A SCHEME is on foot in London to link all the principal railway terminals of the metropolis by means of a vast network of underground freight lines—the purpose being to speed up a large portion of the traffic that now travels on the streets. Experts have estimated that through delay and other causes a loss of $5,000,000 is sustained daily in carrying freight and express matter through the already congested thoroughfares of London.

According to plans formulated, the proposed electric underground freight railway would have a trackage of about 69 miles; and the work would involve an expenditure of £160,000,000. While the scheme is admittedly an ambitious one, the promoters are confident that the linking of the principal distributing centers of London would measurably stimulate that city's commercial activities.

SHANNON RIVER TO FURNISH ELECTRIC ENERGY

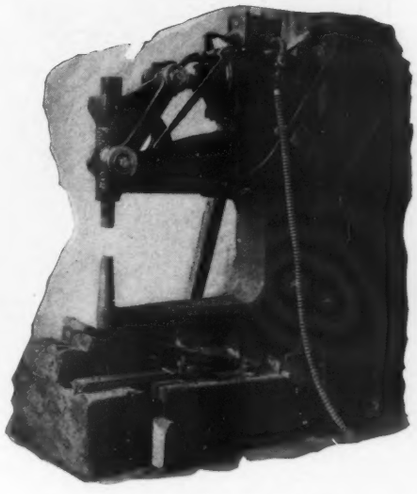
THE waters of the great River Shannon are to be harnessed to furnish a large block of electric energy for domestic and industrial use in the Irish Free State. A contract for the undertaking has been recently awarded; and work has been begun on the first step of the project—the digging of a canal from O'Brien's Bridge to Ardnacrusha, where the head race of the power plant is to be located.

The Shannon has a total drainage area of 4,544 square miles; and from Lough Allen to Limerick, at tide water, the stream has a drop of 144 feet. It will take three years, so it has been said, to complete the work, on which 3,000 men—including 50 engineers—are to be employed. The cost of the undertaking is estimated at $12,500,000.

Model Compressor Plant in New Railroad Shops

THE Madrid, Saragossa & Alicante Railway, one of the most important trunk lines in Spain, has recently completed the erection of new shops, at Villaverde, which are said to be models of their kind. The old shops were located in the City of Madrid; but as they were too small to take care of increased traffic demands and would not permit of expansion, the management decided to build an entirely new plant elsewhere. The present site is about 4⅓ miles outside of Madrid, and was chosen with the future development of the road in mind. The M. Z. A. Railway, as it is familiarly known, now operates about 2,485 miles of trackage.

The Villaverde shops have been constructed for the exclusive use of the permanent-way department of the railroad. They have been laid out along the most modern lines and are equipped with up-to-date labor-saving machinery—in short, with everything necessary for the up-keep of the road, bridges, etc., of a big trunk-line railway. One of the first considerations of the engineers in charge of construction and installation was the compressor plant; and the following short description of it should prove of interest to our readers because of the novel features involved.

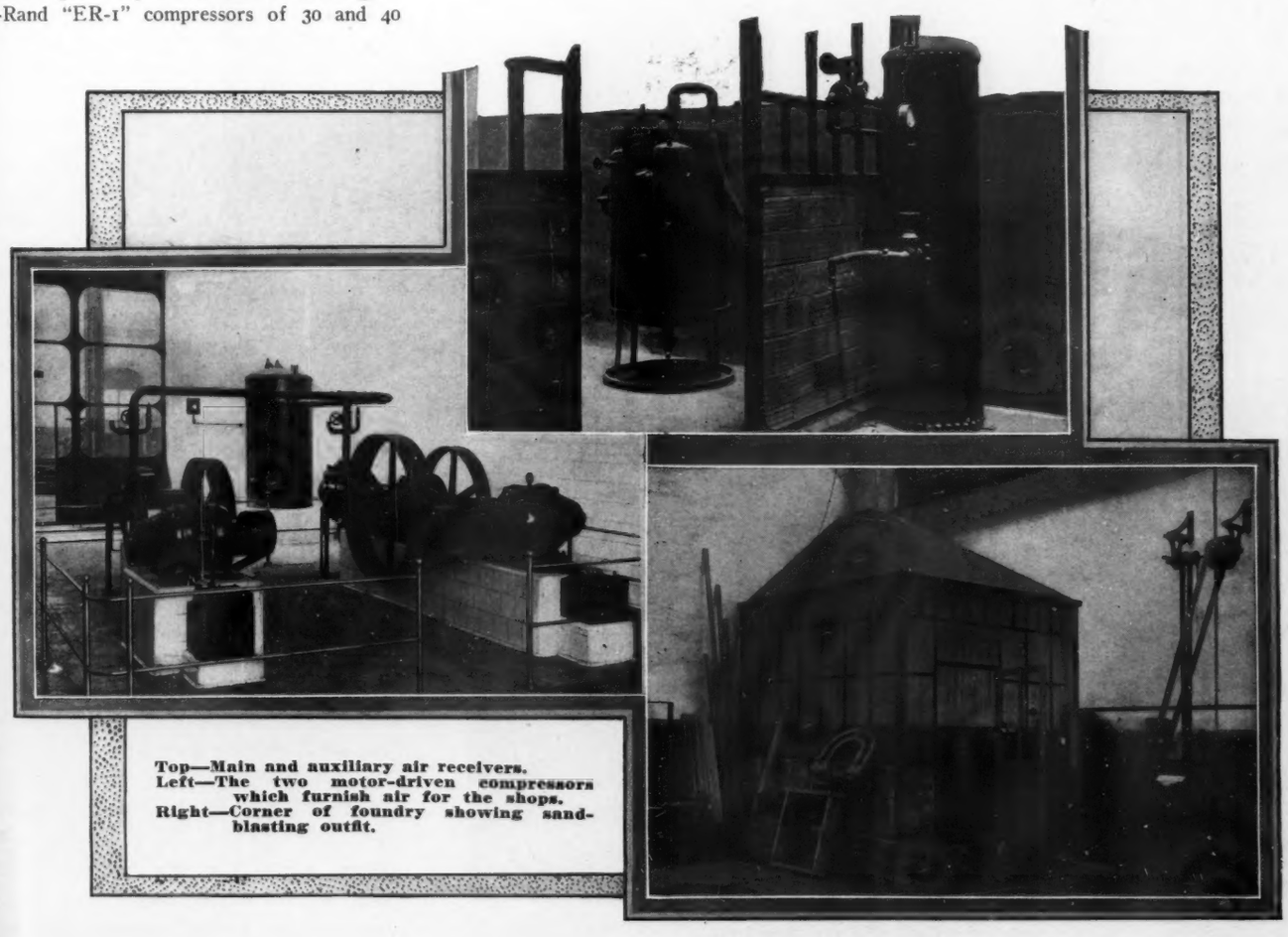


Air-operated bull riveter.

The compressor plant consists of two Ingersoll-Rand "ER-1" compressors of 30 and 40 H.P., respectively. Each of these machines is connected to a Westinghouse motor by short-belt drive, and both compressors are connected to a large air receiver. The delivery pipe is fitted with the necessary gate and safety valves to allow either of the units to be isolated and also to permit starting up one of the machines while the other is in service. An air meter is secured to the main outlet of the receiver; and the pressure gage is placed in a prominent position where it is visible from any point in the engine-room.

In a railway yard, the use of compressed air is anything but constant; and with the two compressors as installed there is assured a varying range of power that can be brought into service according to the number of machines at work. As the engine-room is a large, airy building with tiled floor and walls it was decided to draw the air from the interior instead of carrying the suction pipe to the outside, where the temperature in the summer months is higher than that prevailing inside. The advisability of fitting air filters on the suction is at present under consideration.

The air lines, which vary in diameter, have a total length of about 880 feet. They have been laid so as to serve the forge shop, the main erecting bay, and the foundry. The main line is reduced from a diameter of 3 inches to 2 inches, while the branch lines are 1¼ inches in diameter. All the piping is laid in underground, cement-lined conduits, having a section of 12x12 inches, and rests on wooden blocks



**Top—Main and auxiliary air receivers.
Left—The two motor-driven compressors which furnish air for the shops.
Right—Corner of foundry showing sand-blasting outfit.**

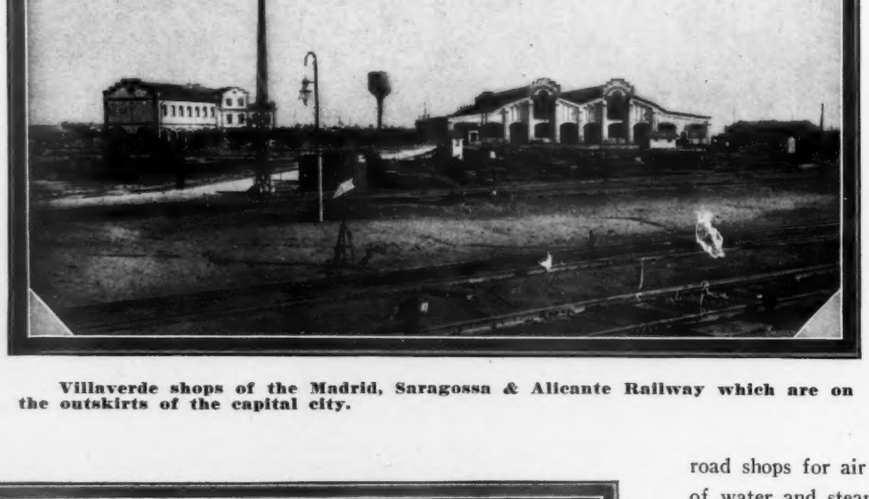
that fit snugly in the trench and are curved in the center to suit the diameter of the piping. At various points along the branch lines are gate valves which permit a section to be isolated at will.

As the pipe lines are long and placed underground, a considerable amount of moisture is precipitated. This moisture is removed by "Dri Air" separators which both condense the moisture and automatically withdraw it from the air. As the air lines lie in trenches or depressions below the main railway tracks running the length of the bay, the separators were similarly placed—thereby increasing their efficiency and preventing the danger of water pockets. The piping is covered with steel plates; but hinged doors are provided wherever there is a header or hose connection to assure ease of access. Each header is fitted with a 2-valve manifold; and I-R coupling is used for all hose lengths.

In this erecting bay the compressed air lines are carried in trenches below the floor level and covered with steel plating with numerous points of access where headers are provided.

The principal applications of compressed air are in the erecting bay. In this bay, riveting hammers, drills, chippers and calkers, etc., are utilized in connection with steelwork for bridges, for stations, for signal posts, and for many other forms of railway equipment.

In addition to the ordinary air-driven riveting hammers, the plant is provided with a pneumatic bull riveter which does much-needed work. This riveter, which is shown in one of the accompanying illustrations, is capable of closing 1-inch rivets on the usual run of structural steelwork. An air-operated bull riveter was chosen instead of a hydraulic bull riveter because the pneumatic machine could be operated directly from the general shop air line—thus avoiding the employment of a somewhat costly hydraulic installation. Not only that, but the selection was influenced by the preference now often shown in railroad shops for air as a motive power in place of water and steam.



Villaverde shops of the Madrid, Saragossa & Alicante Railway which are on the outskirts of the capital city.

One end of the big erecting bay.

The foundry equipment of the Villaverde shops includes, among other up-to-date facilities, sand-blasting apparatus, pneumatic sand rammers, and air-driven wire brushes for the effectual cleaning of small castings. Inasmuch as the sand-blasting outfit operates at a pressure of 45 pounds per square inch, an auxiliary air receiver, with a reducing valve, has been provided. In the case of the sand-blasting outfit, the addition of a water separator has proved of decided advantage by removing moisture which might otherwise cause the sand to "cake."

Compressed air is employed principally in the forge shop for operating the oil-fired furnace which is in service there. Furthermore, at each of the drop-forging machines there is fitted a small bottom blower. This

blower makes it possible for the attendant to thoroughly clean the dies with a jet of compressed air. It is a well-known fact that scale on forgings not infrequently interferes with the proper working of the dies, and the air jet is a handy and effectual means of blowing away this scale.

It is of interest to mention that the plant at Villaverde was designed in its entirety by the Permanent-way Department of the M. Z. A. Railway and was equipped throughout under the close personal supervision of the engineer in charge of installation, to whom we are much indebted for the foregoing article.

PUNCTURE-PROOF PNEUMATIC INNER TUBE

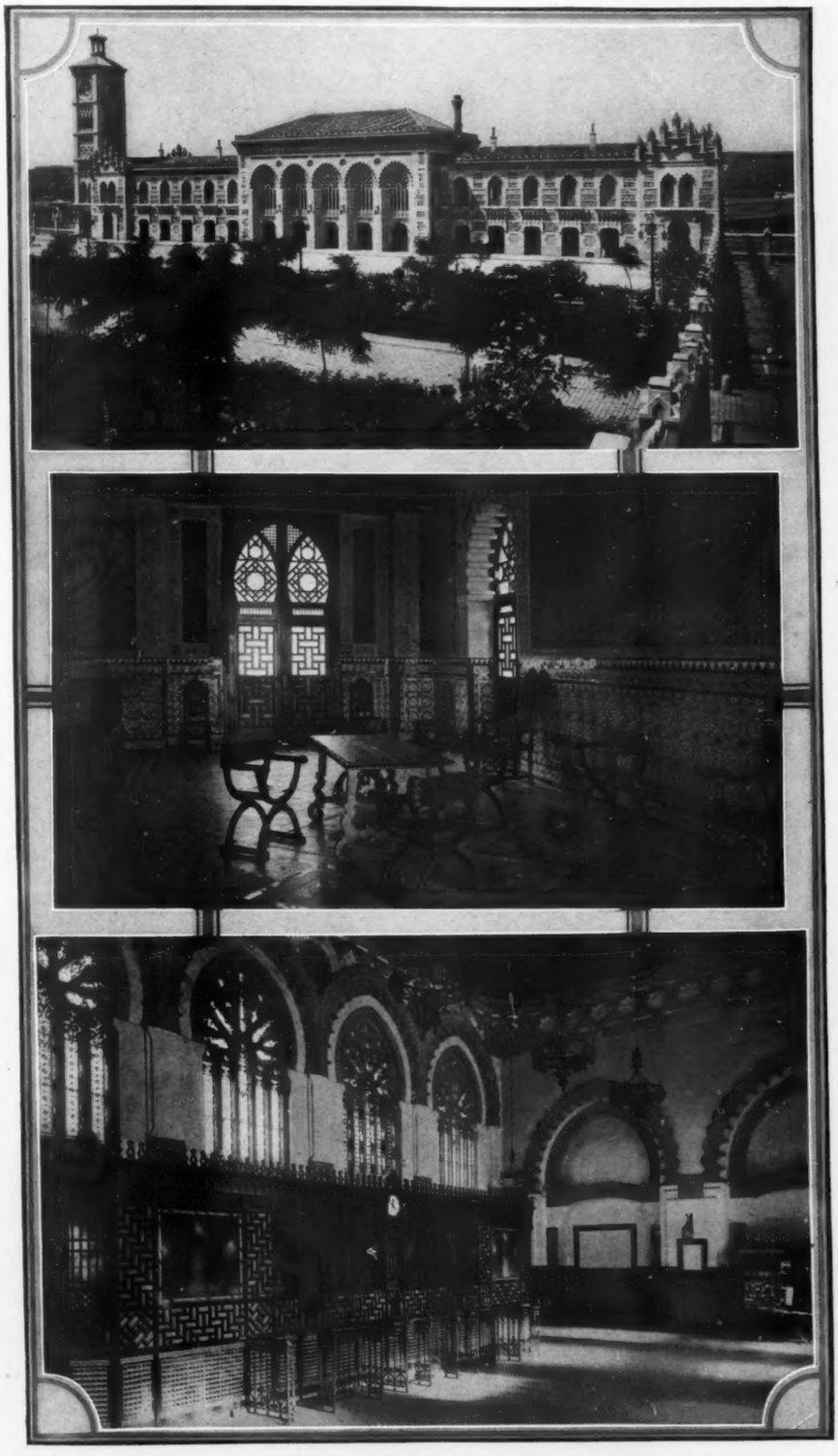
FOR YEARS, tire makers have refused to believe in any but the standard inner tube. It is therefore significant that the "Rubber Ace" puncture-proof, pneumatic inner tube, which has been in use for more than five years, is soon to be manufactured and distributed by the B. F. Goodrich Rubber Company.

"Rubber Ace" tubes are made of pure sponge rubber. Obviously, the air, instead of being held in one container as is now the case, penetrates into millions of little cells forming the honeycomb-like substance of the material and thus renders the tube proof against puncture. Expressed in other words, these sponge-rubber inner tubes assure uninterrupted tire service.

The tube comes in two sections: the main unit, conforming to the shape of the tire, and a wedge. The wedge provides the right fit in the casing under proper compression. In that condition, the "Rubber Ace" tube acts in much the same way as does the ordinary inner tube under correct air pressure. Variable-sized wedges and the manner of installation are features that have made for the successful operation of the new inner tube.

It is said that the life of a "Rubber Ace" inner tube is not limited to one outer casing. On the contrary, it is used with a casing until the tread of the latter is completely worn away and then put in a new casing. This may be continued indefinitely. It has also been brought out that a casing, when used in connection with the puncture-proof inner tube, will give increased mileage. Tests have proved that there is absolutely no movement of the tube in the casing. In conclusion it might be added that the first "Rubber Ace" tube, made over five years ago, is reported to be still in service.

The steamship *Malolo*, under construction at Cramp's shipyard, Philadelphia, Pa., is the largest and fastest passenger-carrying craft so far undertaken in the United States. She quite naturally should have some "biggest thing" in her construction, and this is found in the huge nuts employed to secure the hubs of the propelling screws to the ends of the shafts. Each of these nuts is 28¼ inches across, 12¼ inches thick, and weighs 1,460 pounds.



Top—The Toledo station of the Madrid, Saragossa & Alicante Railway is a beautifully carried out adaptation of the Moorish style of architecture.

Middle—Here is where the King of Spain and other members of the royal family await the arrival and the departure of trains in the Toledo station.

Bottom—Ticket offices and concourse of the Toledo station. Here, too, the Moorish style of architecture is skilfully and faithfully reproduced.

History of a Famous Silver-Lead Mining Camp

After Half a Century of Production, Park City, Utah, Still Promises to Yield Pay Dirt for Years to Come

By BREESE ROSETTE

A WESTERN mining camp that has been producing precious metal for over 50 years is not exactly unique; but when, following such a period of time, its production continues to increase it may lay some claim to interest. Since the early "seventies," Park City, Utah, has maintained a steady output of silver-lead ore, and today is producing more heavily than ever before. Unlike Leadville, Cripple Creek, Goldfield, and many other famous camps, it has never had a boom. Yet, while most of the famous boom camps are now interesting only in a historical way, Park City is still one of the principal silver-lead mining districts of the United States. A total of more than $200,000,000 is its contribution to the world's wealth; and in 1924 its output exceeded that of any previous year.

Facts concerning Park City's earliest history are not plentiful. It seems that ore was first discovered there in 1869 following the encouragement given prospecting by General Connors, then commanding army forces in the territory of Utah. In 1870 and 1871 other finds were made, and a few hundred tons of ore were shipped; but most of these discoveries were small deposits of ore that were very soon worked out. In fact, these first few years did not prove Park City or Parley's Park, as it was then called, to be of much importance as a mining camp. At that time scores of other western districts were attracting much more attention.

An abandoned shaft in the Park City district.

In July, 1872, came the event that changed the aspect of things. The story goes that Herman Budden, an ex-sailor, was going down Ontario Canyon on foot—returning from an unsuccessful prospecting trip. An outcrop of quartz attracted his attention. He broke off a piece of it; and, finding that it contained mineral, he located claims at once—giving his own name and those of two associates as locators. The work of sinking a shaft on the vein was started the next morning. At a depth of six feet the ore widened out; and the claimants offered the prospect for sale for $5,000. No buyers appearing, they continued developmental work until the vein was stripped for more than 100 feet—the width increasing and the quality of the ore steadily improving. The price of the property was advanced to $30,000.

Meanwhile, word of the prospect had reached George Hearst, of San Francisco, and he sent R. C. Chambers, an experienced mining man, to examine it. Chambers at once saw its possi-

Left—Face of high-grade silver ore in a Park City mine.

Bottom—A relic of bygone days—a horse whim used to hoist rock out of an old prospect shaft.

Circle—At the 1,800-foot level of the Park Utah Mine, showing an R-72 drifter at work.

Surface plant of the Park Utah Mine, which is one of the great silver producers in the State of Utah.

bilities; and, after some negotiations, the property passed to Hearst and Chambers for $30,000. More men were then employed, and the work of development continued.

From this beginning developed one of the richest silver mines in the world, the Ontario Mine, the history of which makes an absorbing chapter in the romance of mining. The little prospect that sold for $30,000 has paid over $14,000,000 in dividends, and is known throughout the world because of its remarkable record. Early-day mining records of the Ontario contain startling figures regarding the size and the richness of its ore body and many graphic descriptions of its underground operations.

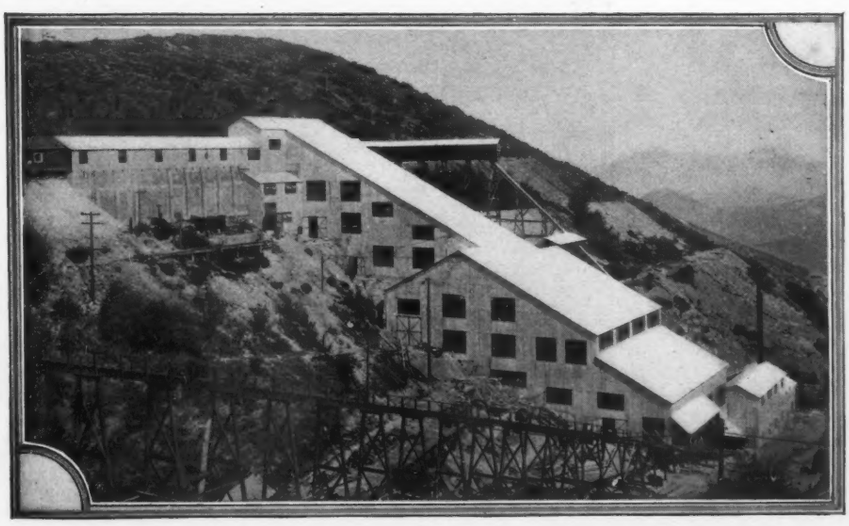
Right from the start there was a struggle with an excessive flow of water. As the workings deepened the flow increased, and the cost of pumping became enormous. It was soon apparent that with added depth the flow would increase to a point where pumping would be out of the question, so a drain tunnel, over a mile long, was driven and connected with the mine workings on the 600-foot level. Another shaft was also started, and there was installed one of the most gigantic pumping engines ever made. It was of the Cornish type, having a flywheel 30 feet in diameter and a 10-foot stroke; and 7,000 tons of quarried rock was used in its foundations. For several years thereafter it was possible to handle the water through the drain tunnel without much difficulty, but as the mine workings continued downward below the 600-foot level the flow increased, and a second drain tunnel was planned to connect with the shafts on the 1,500-foot level. This tunnel was started in 1888, and was driven for over three miles to No. 2 Shaft. The work was carried on to completion in spite of heart-breaking difficulties and at enormous expense. Still larger flows were encountered; and the bore passed through stretches of loose and running ground. It is said that in the latter part of 1892 six weeks were required in driving ahead five feet and in putting in one set of timbers. The cost ran as high as $3,500 a foot in some places. But in 1894, after more than six years of steady work, the connection was made with No. 2 Shaft, and again the water problem was solved.

Although operations have been suspended several times, the Ontario Mine is producing today—more than 52 years after its discovery. A large force of men is employed, and regular shipments of ore are being made. The old Cornish pump at No. 3 Shaft was dismantled long ago, and only a few stone blocks remain of its foundation; the old steam hoist has been replaced by a modern electric one; and the indications are that the mine still has many productive years ahead of it.

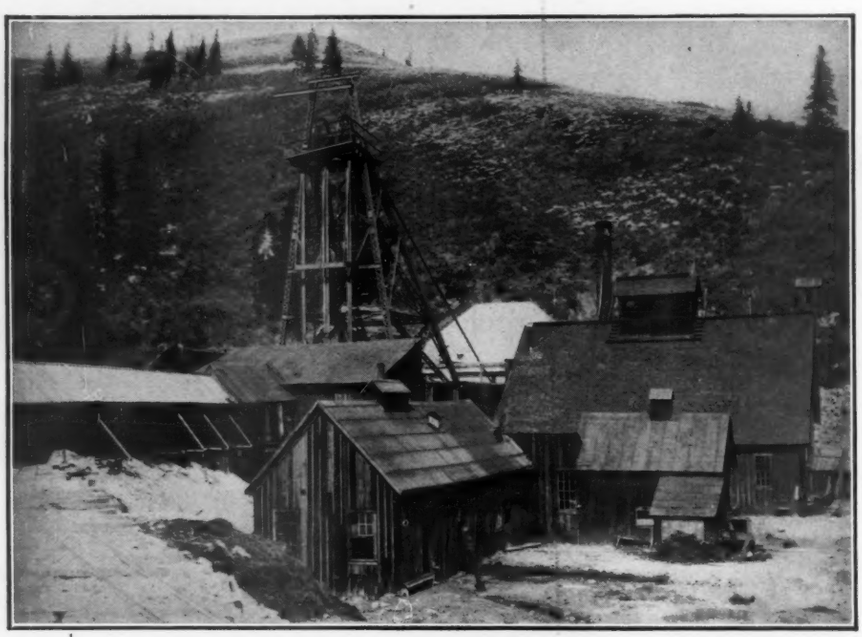
Of course, the success of the Ontario stimulated prospecting, and many other prospects and mines came into being. Many of these were of little importance; but in 1885 the Daly Mining Company, organized by John J. Daly, came to prospect for the western extension of the Ontario lode. After the expenditure of a considerable sum of money ore was opened up, and another rich mine helped to swell the output of the camp. Although not as great as the Ontario, this second mine had a production in 1891 worth more than $1,100,000; and, up to the present time, it has paid in excess of $3,000,000 in dividends.

The success of the Daly led to prospecting still further west. In 1891, the Daly West started operations and soon eclipsed the Daly in point of production and dividends. In the early part of this century the output of the Daly West reached enormous figures; and, as a result, the mine has paid many millions in dividends. Still further beyond the Daly West other properties were developed. Consolidation and reorganization finally brought into being the Daly-Judge, which is today operated with the Daly West by the Park City Mining & Smelting Company. The Daly-Judge holds a remarkable production record.

The year 1892 marked the entrance of the Silver King. Five men, David Keith, Thomas Kearns, W. V. Rice, John Judge, and A. B. Emery—later all famous in Utah mining history, were operating the Mayflower Mine under lease. Observing the trend of the ore, they bought up the Silver King claims to the westward. The paying of dividends started in 1893, and the mine soon became the greatest in the camp. For five successive years—1901 to 1905, inclusive, the annual dividends amounted to $1,-



Ore-concentrating plant of the Silver King Coalition Mines Company.



Shaft leading down into the Daly-Judge Mine, which has a remarknble production record.

300,000. Up to the present time almost $18,000,000 has been paid to stockholders. As a matter of fact, the Silver King paid higher dividends last year than any other mine in the district; and due to its past production and present remarkable output the Silver King may be classed among the really great mines of the world.

The most recent rise to fame is that of the Park Utah Mine. The possible eastward extension of the Ontario ore bodies had apparently been cut off by a fault; and though there had been talk of prospecting for them not much had been done towards that end. In 1916 some Salt Lake mining men acquired the claims adjoining the Ontario on the east, and in 1917 the Park Utah Mining Company started operations—working from the lower Ontario drain tunnel. After many trials and difficulties, a great ore body—rivaling in size and richness that of the Ontario—was opened up in 1921. Since that time this mine has become one of the great silver producers of Utah.

The steady increase in ore production in the Park City district is indicated by the following figures from the *Salt Lake Tribune* of January, 1, 1925, covering the output for the past six years:

TONS OF ORE AND CONCENTRATES

1919.....	79,200
1920.....	102,187
1921.....	83,414
1922.....	170,841
1923.....	183,895
1924.....	237,210

In the development of the district the compressed air rock drill has done its part. In an issue of the *Park Record*, appearing in 1888, is an item to the effect that "the new Ingersoll power drills for the Ontario Tunnel have arrived." The greater part of this tunnel was driven with the old piston drills. Although at that time regarded as the last word in rock-drilling efficiency, by comparison with rock drills of the present day they were slow, heavy, and cumbersome machines. The Spiro Tunnel of the Silver King Consolidated Mining Company is today being driven with Ingersoll-Rand R-72 drifters. Although this type of drifter weighs less than half that of the old piston drill still its drilling speed and its ease of operation are many times superior.

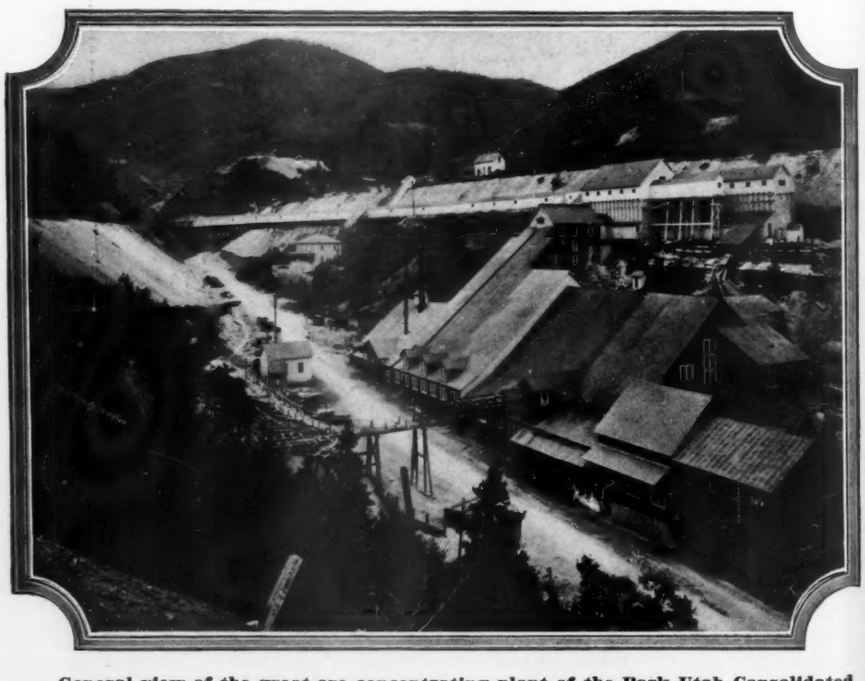
For many years much of the stoping was done by hand drilling. Today the "Jackhamer" and the stopehamer, driven by compressed air, have supplanted the "single jack," and hand miners have given way to machine men.

Many other mining camps, Park City's competitors for fame in the "eighties" and the "nineties" and even in the early years of this century, have long since joined the ranks of the ghost cities. Their collections of deserted ruins and their mine dumps of waste rock are now only reminders of the good old days when hundreds of miners labored in drift and stope, when rich ore discoveries were made, and when blatant prosperity was prevalent. In those camps life was fast and reckless while prosperity lasted; but only too soon were the ore bodies exhausted, and then came the inevitable decline. In contrast, Park City typifies those mining districts that have been blessed with much greater mineral resources and that apparently have many prosperous years ahead of them.

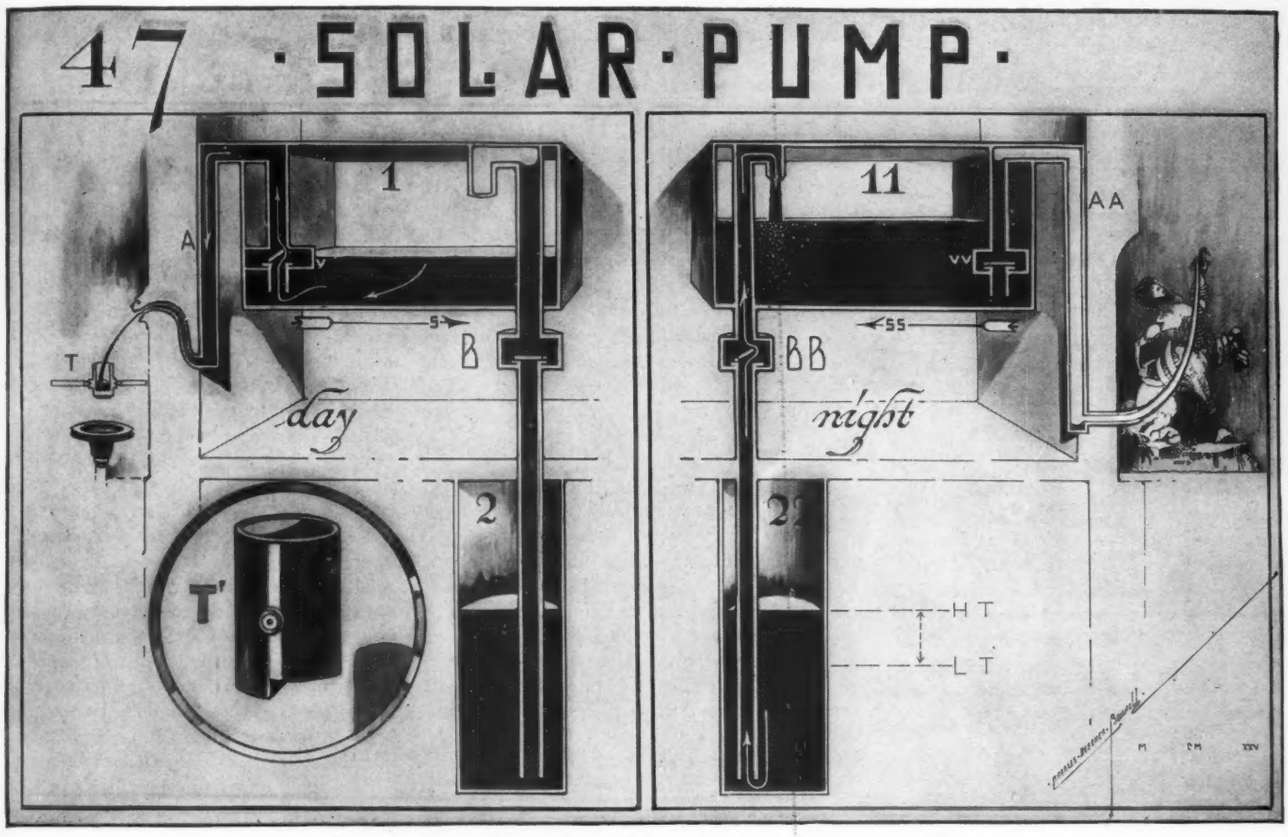
In conclusion, it might be added that the Daly Mining Company, the Park City Mining & Smelting Company, the Ontario Silver Mining Company, and the Park Utah Mining Company, all in the Park City district, have recently consolidated and are now operating as the Park Utah Consolidated Mines Company.

In 1924, for the first time in the history of Trinidad, petroleum products headed the list of exports. The increased importance of petroleum in the island's export business is shown by a comparison with that of 1914. In that year, petroleum products, valued at £67,845, contributed less than 3 per cent. to Trinidad's exports, whereas in 1924 they represented more than 30 per cent. of the total and were valued at £1,367,160.

The record production of crude in 1924 was due to the extension of fields already proved rather than to the opening up of new areas—151,892 feet having been drilled. Out of the 110 new wells sunk in that twelvemonth, 80 were producers.



General view of the great ore concentrating plant of the Park Utah Consolidated Mines Company.



SOLAR PUMP DEVISED BY ANCIENT EGYPTIANS

HERO'S 47th Proposition indicates how the engineering geniuses of that distant day conceived ways to utilize solar energy to operate pumps. In the light of the present demand for high operating efficiencies, the solar pump of Hero's day does not commend itself except for what it was then—little more than a mechanical curiosity. However, the accompanying drawings are interesting because they reveal inventive skill and an accurate knowledge of certain natural forces that could be put to man's service to do work that probably was done in Hero's time by servants or by captives.

The left-hand drawing indicates how the solar pump functioned when acted upon by the sun. The bronze box, 1, had connected with it two pipes, A and B, each fitted with a valve. Pipe B extended to a well, 2. When the sun's rays fell upon the outer surface of the bronze box they heated the enclosed air. The heated air expanded and exerted a compressive effort which, in its turn, forced water out through pipe A and into a cup, T. That cup was a trick contrivance which, when two-thirds full, would suddenly dump itself—that action causing a bird to whistle. The cup was weighted eccentrically and was supported by two horizontal pivots, as indicated by T'. It should be understood that compression within the bronze box caused the valve, V, to open and at the same time kept the valve, B, closed.

The drawing at the right shows how the action of the pump was reversed at night. When the previously expanded air chilled and condensed after the sun had set, that condensing caused water to be drawn up through the pipe, BB, into the tank, 11—the same suction closing the valve, VV. Thus the tank filled itself at night and emptied itself during the day. We are still left to speculate about what happened when the day was overcast and the sun's rays could not reach the bronze box.

GOLD RUSH BY AIRPLANE

PICTURES have been painted times without number of the thrills of stampedes to stake claims in various mining districts the world over. Well-nigh without exception, all these rushes have called for strenuous efforts to be in or near the head of the procession. The race has been pretty generally won by the strong and the fleet. Such was the way the thing was done until recently.

A news item from Canada tells how a much more modern way of reaching their goal has been employed in Ontario by up-to-date claimants. In other words, the stakers have resorted to the airplane to carry them swiftly to the latest objective of a placer rush in northern Ontario at a point southwest of Porcupine. Flying machines have been doing a thriving business; and, as might be expected, the premium on that method of transportation has climbed high. Claims have been staked which are yielding, so it is said, as much as $8 a yard.

GREAT RESERVOIR ADDS TO LONDON'S WATER SUPPLY

THE water-supply system of the City of London has recently been increased by the addition of a new reservoir, known as Queen Mary's Reservoir, which is of interest because it is the largest reservoir in the world having artificial embankments. This impounding basin covers an area of about 723 acres, and has a capacity of nearly 7,000,000,000 gallons.

As the site selected was on flat ground, the entire bottom of the reservoir had to be excavated to a depth of six feet below the surface—the material thus obtained being used to rear the enclosing embankments which rise to a height of 38 feet. The inner slope of the embankments is lined with concrete slabs six inches thick, and the outside, covered with rich soil and loam, is to be planted with ornamental shrubs. The exterior outline of the reservoir is that of an irregular 7-sided polygon with rounded corners, and advantage is taken of this to add to the scenic charm.

WATER WITCH DOES WONDERS

THE water witch is said to be an important factor in oil-well engineering. It solves the problem of locating the source of water in oil wells so that the water may be kept at bay by cement rightly placed. In short, it is an ingenious application of electricity. Clear water, without salts in solution, is a non-conductor of electricity—its conductivity increasing rapidly with the salt content. All subsurface waters carry some salts in solution, while surface waters contain little or none.

The *modus operandi* of the water witch, as described in *Natural Gas*, is to lower a tube to the bottom of a well and to pump clear water into it until the fresh water has entirely displaced the mineralized water. Two electric wires, terminating in electrodes, are then run down the well. As the wires approach the spot where the mineralized water is entering, the electrical resistance is lowered—becoming lowest at the point of ingress.

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EDITORIALS

RECLAMATION

THE City of Chicago is inaugurating a magnificent scheme of "reclamation," for a distance of seven miles along the shores of Lake Michigan, which is to add to its system of parks and boulevards an area one and one-half times as great as that of Central Park in New York City. Bulkheads are being constructed, and a fleet of trucks, three dredges, and a score of barges are helping to fill in earth at the rate of 10,000 cubic yards a day. Landscape artists have planned lagoons, islands, bridges, and other picturesque features; and the cost of the undertaking is estimated at $100,000,000.

Comparatively little is being done to keep the world informed of the work of reclamation underway in New York City. There they are continually reclaiming vast spaces not from the surrounding waters but from the atmosphere. Old New York, the business portion of it, is being rapidly transformed into New New York. Old and shabby buildings—which average five stories or less, and in which much space is wasted on account of their thick walls of masonry—are fast disappearing. Instead, there are steel and concrete structures, twenty stories high and upward, which are built with a studied economy of space and a convenience of arrangement that make for enormous gains. It may be claimed that three-quarters of the space occupied by these new buildings is reclaimed from the air, and some of it—that taken up by the basements and the sub-basements—from the earth beneath.

The curious, though now familiar thing about it is that air—compressed air—is the most important agency employed in this work of reaching upward and downward. Men laboring in pneumatic caissons find the rock below on which to lay a sure foundation; air-driven drills are used to cut away the rock wherever necessary; pneumatic riveting hammers follow the steelwork up into the sky; and air has been employed in the first place to get many of the essential materials from the mines. This kind of reclamation is as sure for the future as civilization, itself.

SCHEME TO HARNESS ENTIRE TENNESSEE RIVER

NO matter how skilfully utilized, coal or any other fuel when once consumed gives out all the heat or energy that it possesses. That is to say, its power to do work is then exhausted and nothing remains to show what has happened save a residue of soot or ashes. Not so with the power latent in falling waters—the same descending waters can be employed again and again during their journey downward, and thus the volume of energy can be multiplied to an astonishing degree.

Up in New England there is an unpretentious stream—the Deerfield River—which, by cunning engineering and the establishment of plants at strategic points, has been made to generate many thousands of electrical horsepower and to furnish needful energy to scores of communities and a great range of industrial activities. Following out the principles so well applied in the case of the Deerfield, it is now proposed to harness in a kindred manner the entire Tennessee River and to make available a tremendous aggregate of from 1,000,000 to 1,250,000 horsepower! In short, Muscle Shoals, of which we have heard so much, would be only one unit in an assembly of central stations.

Should this project be carried out it would be possible to transmit energy for hundreds of miles into six of our southern states and to give to 12,000,000 people the benefits and the conveniences of a tremendous block of electrical energy. It is easy to visualize what a boon this would be. In short, it would provide power for a vast array of applications which could be had otherwise only by transporting and burning something like 8,000,000 tons of coal annually. By utilizing the latent energy in the Tennessee River, that 8,000,000 tons of coal could be sent elsewhere and used to advantage in sections of the country where measurable amounts of hydro-electric energy could not be developed. This is prospectively an amazing example of conservation.

REFRIGERATOR CARS HELP TO LOAD OUR TABLES

REFRIGERATOR cars have become a commonplace—we see them threading their ways over all our railroads, and they are much in evidence at every sizable terminal. Even so, how many of us appreciate what these conveyances mean to our comfort, our convenience, and our well-being? It is probably not an exaggeration to say that the physical fitness of the American people as a whole is largely due to the service rendered by refrigerator cars.

Refrigerator cars have virtually brought to every threshold throughout the length and breadth of the land the dietary abundance of varied agricultural regions. The semi-tropical fruits of California, Florida, and other sections of the Southland are to be had nearly as freely along our northern border as they are in the sunny sections where they grow. Similarly, the products of the Northland are sent to our farthest southern limits, while perishable foodstuffs of other sorts are thus rushed hither and thither from point to point, daily giving the plenty of the farm to the unfruitful areas of crowded cities. Not only that, but seafoods of many kinds are transported from the coasts to the remotest of our interior districts.

The time was, and that not so long ago, when the ice used in refrigerator cars was the ice made by Nature during the winter months in our northern states. This, in itself, limited the field of service of these cold-storage vehicles. Today, most of the ice employed in icing these cars is manufactured—the ammonia compressor being the principal medium by which this miracle of man's devising is performed. In fact, mechanical refrigeration is working wonders in many other departments of industry and in our daily life in innumerable directions. Strange as it may seem, the ice house of our forebears is likely ere long to be an infrequent curiosity or little more than a tradition.

TRYING TO KEEP TABS ON ELUSIVE MACKEREL

EVERY now and then the public is reminded by competent observers that some one of its widely used foodstuffs is in a fair way to disappear. The latest of these is the appetizing mackerel, which has satisfied and delighted the palates of millions of us for generations.

Where it was once possible to harvest along our Atlantic seaboard nearly every season immense catches of these full-flavored fish, their appearance in large quantities in latter years has been intermittent. Not only have our tables lacked this toothsome delicacy on occasions but an industry which employs a large fleet and numerous crews has been imperiled by the fluctuations in the catch—fluctuations which have seemed to indicate gradual depletion over a considerable period.

Now there is a commission or a committee representing Canada, France, Newfoundland, and the United States, engaged in investigating the life history of the mackerel; and it is hoped that these inquiring experts will be able to discover why there should be such wide variations in the number and the sizes of the annual schools and then to recommend measures which will protect the fish and give them the needful opportunities for their sustained reproduction and, possibly, stimulated multiplication. In this absorbing economic research

many mackerel are being tagged with little celluloid bands for identification; and it is believed that in this way as much may be learned about the mackerel as has been in the case of the salmon.

PROSPERITY LOOMS LARGE IN INDUSTRY

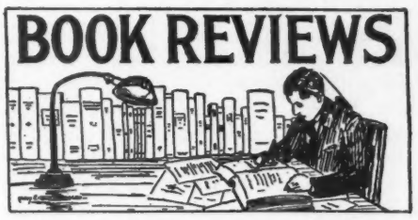
SUCH, in substance, is the keynote of responses made recently to a series of interviews initiated by *The New York Times.* Throughout the length and breadth of the land, the reports were enthusiastic over the outlook for trade and industry in all of their departments. These reports were not haphazard opinions expressed by inconsequent persons but were the conclusions arrived at by executive officials of local chambers of commerce in no fewer than thirty-two of America's important cities.

The headings of the different reports read, in part, as follows: Buying power shows strength; stores doing phenomenal business; production 75 per cent. of normal; building has broken all records; bank deposits have doubled; best business since the war; commercial feeling is confident; etc., etc. To be specific, we are informed that factories are working overtime on the Pacific coast and that the lumber business there is showing greater activity through heavier domestic demand. Despite the drought in the Southern and the Mississippi Valley States, grain and forage crops were not seriously affected; and an extraordinary cotton crop is confidently expected. In some states, and this applies especially to those of the Middle West, both crops and prices are better than they have been for several years past. Construction work, railroad building, and public improvements generally, calling for the disbursement of great sums, are being pushed forward in both the West and the South; and a very large percentage of our mills and factories are working at a rate that has not been equaled for some while.

Taking it all in all, the United States can look forward to a period of assured prosperity which, in its turn, should have its beneficent reflexes the world over.

AUTOMOBILE NOW "SHIP OF THE DESERT"

IN the Syrian Desert, the automobile has displaced the camel of the caravans as completely as it has superseded the horse on the highways of the United States. The desert, that was once the most serious barrier to intercourse in the East, has become an important route of commerce and travel. Motor cars are making scheduled trips from Aleppo to Bagdad, to Beirut, to Damascus, and to all the intermediate stations with astonishing regularity. The trip from London to Bagdad can now be made in seven instead of in from twenty-two to twenty-five days, as formerly. Not only is the East thus brought nearer to Europe, but the Moslem world, itself, is brought more closely together for the good of all concerned.



BRAZIL AFTER A CENTURY OF INDEPENDENCE, by Herman G. James. An illustrated volume of 587 pages; published by The MacMillan Company, New York City. Price, $4.00.

THE world at large has a decidedly imperfect conception of what has been achieved in Brazil during the 100 years of that country's independence. Part of this lack of understanding is due to a realization of the territorial magnitude of the country and to the knowledge that only a comparatively small share of the natural riches of the nation have yet been utilized to any commensurate extent. That is to say, Brazil is still at the end of a century in a state of economic and industrial evolution; but, even so, her people have achieved much that is notable, and this is significant of what she may yet become as a power among the great nations of the world.

Mr. James has done a helpful piece of work in writing the book he has about Brazil. He tells most of us just what we should like to know about Brazil, and he tells his story in a clear and readable way—taking the viewpoint of an intelligent American who sees what is really distinctive of the country. The business man, the tourist, and any other person desirous of knowing what Brazil has done and where she stands today will find Mr. James' book interesting, informative, and, withal, entertaining and authoritative.

CONCERNING THE NATURE OF THINGS, by Sir William Bragg, K. B. E., D.Sc., F. R. S. A volume of 250 pages, with numerous illustrations, published by Harper & Brothers, New York City. Price, $3.50.

THE biggest of material things rests, in the last analysis, upon a foundation composed of an aggregation of infinitely small things—myriads of atoms. Therefore, the structure of atoms is something about which all of us should know something and some of us should know a great deal more than we do in order to grasp the meaning or the physical processes of material things generally.

The average reader is little disposed to spend time reading about atoms, because the presentation of the subject is usually involved and decidedly technical. Sir William Bragg makes this excuse no longer an acceptable one, because he has succeeded in handling his subject in so lucid and so fascinating a manner that he can hold the attention of a very wide range of readers and instruct them while entertaining them. The nature of atoms, as well as the nature of gases, liquids, and crystals, are disclosed by the author with exceptional clearness; and his treatment of these several things places the inquiring public deeply in his debt. It is not often that scientific topics are handled so successfully.

LOCATING THE IRON TRAIL, by Edward Gillette. An illustrated book of 172 pages, published by The Christopher Publishing House, Boston, Mass. Price, $2.00.

DESPITE the much done by the early explorers, trappers, stockmen, and pioneer settlers to open up America's great West, the ultimate development of that enormous virgin region was brought about by the railways which made little of long distances and carried with them the assurance of speedy transportation. But before those roads could be built it was indispensable to their economical operating that their lines should follow routes that would not overtax the locomotives nor lay on them too heavy a burden of fuel consumption in moving trains from point to point.

Mr. Gillette's book describes how the routes for the "iron trails" were first blazed; and he reveals to the matter-of-fact public the wealth of romance involved and the many hazards faced in determining the lines to be followed before a single sleeper or a length of rail could be laid. The book can be read with profit by many of us that are unaware of the part played by the pioneer railroads of the West not only in opening up that vast storehouse of natural riches but in unifying the nation as a whole.

THE STORY OF MAN'S WORK, by William R. Hayward and Gerald W. Johnson. A book of 245 pages, published by Minton, Balch & Company, New York City. Price, $3.00.

THE purpose of this book is to provide information from which to draw a working knowledge of the economic system under which most of us live. As the authors express it: "It has no just claims to be called a work on economics: it is really an attempt to show to the reader that the subject is worth studying." In short, the book recites the struggles and the labors of millions of men and women throughout hundreds of centuries in their continued effort to build up and to preserve rather than to tear down and to destroy. What we are and what we have today we owe in great measure to the efforts of the people or peoples described in the pages of this book. William R. Hayward is the principal of one of the high schools in New York City, while Gerald W. Johnson is a professor at the University of North Carolina. Together, they have turned out a very readable account of the progress and the problems of man's work from primitive beginnings down to our own day.

A flow calorimeter for specific heats of gases is the title of Scientific Paper No. 503, prepared by Nathan S. Osborne, H. F. Stimson, and T. S. Sligh, Jr., of the United States Bureau of Standards. Price twenty cents.

A hot-wire anemometer for measuring air flow through engine radiators. This pamphlet, known as Technologic Paper No. 287, has been prepared by Carl G. F. Zobel and L. B. Carroll of the United States Bureau of Standards. Price five cents. Both of these pamphlets can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

The British school of Archaeology in Egypt has been able to carry the history of Egypt back over a period of 14,000 years.

FINE CEMENT PRODUCES STRONG CONCRETE

AFTER ten years of research work, just completed by the United States Bureau of Standards, new light has been thrown on the subject of finely ground cement. That fineness is a vital characteristic of Portland cement has long been known, but information was lacking as to the exact effect of such fineness on cement over long periods of time. This information is now available; and experiments have proved that finely ground cement makes concrete stronger, especially if a greater amount of cement is used with the sand and gravel.

Ten years ago test cylinders of concrete were made of five brands of cement and Potomac River sand and gravel. These cylinders were first kept in moist air for 28 days and then exposed to Washington weather for periods up to 10 years. Specimens broken after 6 months, and after 1, 2, 3, 5 and 10 years showed greater strength than similar specimens of normal cement. The older specimens showed less increase; but the tests proved conclusively that finely ground cement adds to the strength of the concrete, especially with rich mixes. With the growth of the industry the fineness of cement has increased until at present, under the national specification or quality standard, 78 per cent. passes through a cement sieve having 40,000 openings per square inch.

CHEMISTRY GIVES US SYNTHETIC WOOD ALCOHOL

THE production of synthetic methanol, wood alcohol, is said to be one of the most revolutionary achievements of the chemical industry in this century. The Badische Aniline & Soda Fabrik, which has to its credit the discovery of alizarin—Turkey red—and artificial indigo, owns and operates the basic patents from which the production of methanol was developed. The patents were taken out in 1913, but the war interfered with the perfecting of the process.

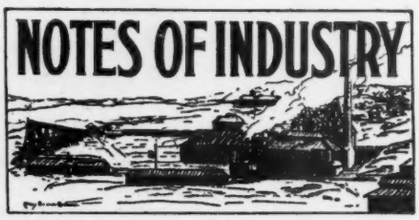
The principle on which the German process is based is analogous to that of the Haber-Bosch ammonia process, that is, carbon-monoxide gas and hydrogen are combined under a pressure of 200 atmospheres and at a temperature of about 752°F. in the presence of a catalyst, probably finely divided pure zinc oxide. It is interesting to learn that a Frenchman, Georges Patart, has recently discovered a somewhat similar process for the manufacture of synthetic wood alcohol.

In planning for the extension of the water-supply system of Honolulu, the water commissioner has estimated that the city's present population of about 100,000 will have reached a total of 270,000 within the next three decades.

Statistics show that 405,344,000,000 cubic feet of manufactured gas was consumed in the United States in 1924. This is the largest consumption on record.

AMMONIA SAVES A BANK

A RECENT attempt to rob a bank at Good Thunder, Minn., was foiled by a contrivance installed by the cashier—and not advertised. As an emergency measure, a gallon bottle containing a mixture of ammonia and mustard had been placed between the duplicate doors of the vault. When the robbers, after shooting up the town, blew off the outer doors, the ammonia bottle was broken and the fumes were so strong that the robbers fled without a cent.



More than one-half of the window glass, one-third of the plate glass, and one-eighth of the bottles used in the United States are manufactured in Pittsburgh, Pa. It is interesting to note that the glass-making industry was started there as far back as 1797.

The world's deepest bore for oil, which is still in the process of drilling, has reached a depth of 7,200 feet. The well is being sunk on the Simpson Ridge anticline, near Laramie, Wyo.; and when the Dakota sand is reached it is expected than an enormous producer will be brought in.

Canada now obtains a total of 3,570,000 H.P. from her falling waters; and the capital invested in her hydro-electric plants, including transmission and distribution systems, amounts to $766,758,000. Fourteen years ago, in 1910, the investment stood at $121,000,000, showing that the Dominion has spent nearly $46,000,000 annually since then in the development of her water-power resources.

A limestone quarry at New Braunfels, Tex., was recently the scene of a blasting operation that deserves to go on record for the rapidity with which it was executed. A total of 93 holes, averaging 60 feet in depth, was loaded and fired in 3½ hours—throwing out and breaking up 97,286 tons of rock. The holes were drilled in a single row, 18 feet back from the face of the quarry and 12 feet apart. Into them was loaded 31,050 pounds of Duobel, a special DuPont high explosive; and the cartridges used were 4x16 inches. They were slit and tamped, and then fired by Cordeau-Bickford fuse. Thirty-five men were employed on the job.

In cigar factories at Key West, Fla., hundreds of men work close together at long benches rolling tobacco leaves. As they toil they listen to stories, in Spanish, read by a man on a raised platform. These men are chosen for their voice and lung power—reading all day with only occasional 15-minute periods for rest.

The world's largest telescope, which is [illegible] the Mt. Wilson Observatory, is soon to be ou[t]classed by an instrument now being built fo[r] the Frye Observatory, at Seattle, Wash. Th[e] new telescope is expected to reveal 400,000,00[0] stars, while the Mt. Wilson telescope, whic[h] has a smaller reflector, makes 320,000,00[0] heavenly bodies visible.

For making coils or spirals of small-diameter brass or copper tubing, the Bureau o[f] Standards has found that ice works satisfactorily. The tube is filled with water and the[n] packed in salt and ice, which soon causes th[e] water to freeze. After bending, the ice melts an[d] runs out—leaving the tube clean and empty.

Discovery of zinc in the Sudbury nickel district of northern Ontario is said to have le[d] to the formation of plans by an American syndicate to test the size of the deposits by drilling. At the present time the Province o[f] Ontario produces no zinc—British Columbia b[e]ing Canada's chief source of supply.

A water-supply company in Hackensack, N[.] J., is using brass piping for the service lines that lead from the street main to the curb line, and has recently purchased 125,000 feet of piping of this kind. Waterworks engineers, generally, are in favor of the utilization of brass for this purpose.

Interesting particulars are at hand concerning the world's longest telephone cable, recently completed, connecting New York and Chicago. Begun seven years ago, it represents a total investment of $25,000,000. It is 861 miles long—717 miles of aerial cable supported by 25,700 poles, and 144 miles of cable in underground conduits. The cable is 2⅝ inches in diameter and weighs approximately 17,375 tons. It contains 447,000 miles of wire, and in the laying of it 5,750,000 wire splicings were required. It is the equivalent of ten open-pole wire lines of the usual type; and it will handle 250 telephone messages and 500 telegrams at the same time.

It is announced in the press that Dr. Colin G. Fink, head of the division of electrochemistry at Columbia University, New York City, has perfected a process of chromium plating by which it is possible to produce surfaces that are much harder than those of any other known metals and with a finish having twenty times the life of nickel plate. Next to the diamond, says Doctor Fink, the new plating will be the hardest substance in existence, and it can be made at a cost not much in excess of that of nickel plate.

The construction of a bridge over the Mississippi at New Orleans is now practically assured—General Harry Taylor, chief of engineers of the United States Army having approved the revised application. The bridge will have a central span 130 feet above sea level, and there will be no interference with navigation. The railroad approaches will be more than a mile and a half in length.